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NEW ZEALAND'S ENERGY FUTURE

A SUSTAINABLE ENERGY SUPPLY AFTER MAUI
A DISCUSSION PAPER

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 ISBN 0-908993-35-8

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foreword

Depletion of the Maui gas field has quickly imposed a new framework for New Zealand's energy future, beginning with the immediate concerns of electricity supply but in the medium term moving to the much more fundamental concern of securing adequate primary energy sources to meet ongoing demands for essential energy services.

Maui gas meets almost 25% of our total primary energy supply. Other primary energy sources include geothermal, coal, other natural gas supplies, oil, hydro and other renewable sources. Yet despite plentiful primary energy sources, New Zealand remains vulnerable to the risks of shortages of consumer energy including electricity and transport fuels. It also risks increased dependency on imported fuels with the consequent higher costs to consumers.

The dry year electricity crisis at the beginning of 2003 was a potent reminder of the reality of life in a nation with an energy shortfall. But this crisis was fundamentally different from other post 1990 supply shortages because it was policy based. It largely reflected the lack of a coherent policy framework for future planning and investment in the development of new primary energy resources for this country.

Recent history shows that New Zealand is increasingly vulnerable to delays in commissioning new electricity generation plant, and increasingly reliant on imported sources of primary energy. It is not as if the depletion of the Maui gas field was not well known and oft predicted, or that dry years are not expected. But even with this knowledge, New Zealand has failed to ensure the levels of investment required to manage the risks of electricity supply shortfall.

Our thinking must go far beyond just the issues surrounding electricity supply and demand; we must focus on primary energy sources. The transition from dependence on Maui gas to other alternative primary energy supplies needs to be managed assertively if we are to avoid energy shortages which would potentially cripple New Zealand.

Levels of exploration have not been adequate to secure gas reserves. Public policy initiatives to avoid wasteful use of energy have languished. And despite government policy objectives for sustainable economic growth, the market share of consumer energy provided by renewables has reduced. The delivery of energy services requires decades of large capital investment, and this has just not been undertaken.

But the Centre for Advanced Engineering does not just want to point to the problems. This document has been produced to stimulate robust public debate on the choices available to New Zealand, and so help plot a more sustainable energy policy for the future.

The information contained in it is based upon the extensive work undertaken by CAE over many years. It draws on its various studies and reports covering energy supply and demand, risks and vulnerabilities, energy efficiency, distributed generation and renewable energy options for New Zealand. In doing this the authors paint a coherent picture of the current New Zealand primary energy supply situation and the likely influences that will determine outcomes over the near term.

We have drawn upon public information to outline the issues and to inform New Zealander's of their future choices. The private and public sector must work together to actively pursue all the options and ensure the necessary investment to secure our energy future is made. There is no silver bullet available to New Zealand.

Your comment is welcome. We look forward to contributing to a strong public debate, and ongoing robust analysis that will ultimately drive the equations for success.

R J (George) Hooper
Executive Director

exective summary

THE LEGACY OF MAUI

New Zealand is an energy-rich country yet in the absence of any identified strategy to secure primary energy sources for the long term, it will once more return to a situation of dependency on foreign energy markets.

The Maui gas discovery in 1969 gave to this country a one-off opportunity to secure its energy future. Catalysed by the oil crises of the 1970s, New Zealand took action that was at the forefront of world thinking and effort at the time. As a consequence of the decisions taken, New Zealand self sufficiency in primary fuel improved dramatically to over 85%, and a gas market evolved to become a key part of New Zealand's energy sector and industry infrastructure.

But the security and flexibility that the New Zealand energy market enjoyed as a result has had the counter effect of diminishing the importance of primary energy in people's minds. For most people and businesses, access to energy has been taken for granted. We require and expect electricity, natural gas and transport fuels to be readily available and to be able to increase or decrease consumption at will. New Zealand's focus turned to consumer energy requirements, market governance issues and investment efficiency.

With very few exceptions, New Zealand has had the benefits of inexpensive energy without giving thought to the future. This year, the onset of another winter power shortage and the redetermination of the Maui gas reserves have suddenly caused a refocus on energy supply.

But, behind the delivery of energy services lie decades of essential large capital investment in generation, transmission and distribution of electricity, as well as investments in the discovery, development, production and distribution of gas and other primary fuels. Decisions taken during development of the Maui discovery anticipated such investments plus investigation into alternative energy forms and ongoing energy planning. Because there was no coherent national action, these imperatives were not addressed.

Critical investments in further delineation of primary energy sources and expansion of energy reserve capacity have simply not occurred. Inadequate levels of exploration investment has led to failure to secure gas reserves adequate to maintain gas markets. Public policy initiatives to avoid wasteful use of energy have languished and, despite government policy objectives for sustainable economic growth, the market share of consumer energy provided by renewables has reduced. The opportunity for New Zealand to leverage its investment in Maui to secure a sustainable future energy supply has simply disappeared.

Instead the New Zealand energy sector is rapidly entering a period of transition and uncertainty which will be characterised by uncertain supply, higher costs, and a loss of flexibility and reliability. In particular, gas supplies to the electricity industry will be tight and major gas users will have to consider alternatives. If nothing is done to secure adequate indigenous primary energy sources the alternative is to import. The question then becomes from where, at what price and for how long?

The risks to the New Zealand economy are significant. New Zealand is in danger of reverting to a situation where it becomes once more dependent upon and vulnerable to global oil markets. Shut down of major gas-based industries and/or postponement of new power plants could become major disincentives to those considering further investment in our manufacturing industries. If these markets contract, incentives for gas exploration also decline and the supply side will contract further – leaving New Zealand further exposed to economic downturn and the vagaries of global energy markets.

NEW ZEALAND'S ENERGY PROFILE

New Zealand's energy sector has experienced a period of significant change since the development of the Maui gas field and the reforms of the 1980s. As importantly, the onset of Maui gas into the New Zealand fuels mix signalled a radical repositioning of natural gas as New Zealand's primary fuel source for thermal power generation and allowed significant substitution of foreign oil in our domestic fuels market.

But whilst the way the sector operates and the dynamics of the industry itself may have changed, the underlying fundamentals of energy supply remain unchanged. Primary energy sources, either indigenous or imported, form the resource base available to a country for meeting its future consumer energy demand as input into virtually all industrial, commercial, transport and household activities. From this resource platform, patterns of energy use are determined by the industrial and transport mix of a country, its economic growth, and by individual decision on energy efficiency and conservation.

The questions from a fuels perspective are:

- to what extent can oil and gas from indigenous sources supplement current Maui reserves
- what likely contribution to primary energy supply can be anticipated from new renewables
- how might demand for imported fuels be reduced through fuel switching, demand management and the uptake of distributed generation technologies.

The answers are dependent on patterns of energy use and demand growth.

NEW ZEALAND'S ENERGY RESOURCES AND FUTURE SUPPLY OPTIONS

New Zealand must maintain an efficient energy sector with security of supply during and beyond the transition phase begun with the decline of the Maui gas field. The close historic coupling between economic growth and energy consumption means that meeting future economic growth target will require similar growth of energy supply, efficiency gains notwithstanding.

About 30% of New Zealand's energy consumption and 70% of its electricity comes from renewable sources. This is very high by international standards but is declining, particularly because of the favourable economics of combined cycle gas technology for electricity generation and the increasing contribution of transportation in the total energy demand. The question that arises is how New Zealand might act to meet projected future growth in energy demand, particularly for electricity generation.

Oil and gas

New Zealand is self sufficient in all energy forms apart from oil. A complicating factor is that currently imported products meet oil supply almost entirely. Most indigenous product is exported, leaving New Zealand about 34% self-sufficient in liquid oil products, a proportion which is falling and will do so more rapidly as Maui is depleted.

The replacement of gas reserves is critical to managing the transition phase of the energy sector away from Maui gas surpluses. Recent investment history within the electricity sector underscores the vulnerability of generation to any disruption in natural gas supplies and the increasing vulnerability to delays in commissioning new plant.

Oil and gas inventories are declining because there has been inadequate investment in exploration to replace the reserves being consumed. New Zealand is not short of prospective targets, but there are few incentives to explore outside of Taranaki, even at expected future gas prices.

Government has not placed sufficient urgency on securing new oil and gas supplies and as a result has effectively lost control of its hydrocarbons inventory. Small discoveries make little difference to the national inventory, and even new fields of moderate size such as Pohokura do not replace the role that Maui has had.

Coal

Coal dominates New Zealand's energy inventory. Over 80% of the total in-ground resource is in the South Island, mainly in the huge lignite deposits of Southland and Otago. There are other large reserves in the Waikato, Taranaki and the West Coast.

Coal has the potential to contribute a far higher proportion of New Zealand's primary energy supply than it has since the development of hydro power and gas reserves over the last 40 years or so. However, without a rethink of the potential role of coal in the New Zealand economy and more robust forward planning, there is likely to be formidable barriers to the development of new large coal mines. There is also increasing pressure under international agreements to limit CO_2 emissions, causing a strong disincentive for development of coal-fired generation plant. Yet the certainty of knowledge about New Zealand's coal resources means that it is arguably the most robust option there is for long-term security of electricity supply.

Advanced fossil fuel technologies are leading to fundamental changes in thermal power generation world-wide. These need to be fully assessed and weighed against the risk of future supply shortfall from reliance on imported energy feedstocks.

Renewable energy

New Zealand's renewable energy sources comprise hydro power, geothermal and the new renewable such as wind, biomass and solar. Despite New Zealand having a wide experience in hydro and geothermal energy, there are substantial barriers to realising their potential for contribution to New Zealand's energy supply in the immediate future.

Geothermal energy could make a significant additional contribution to New Zealand's generating capacity, and it will be difficult to meet the Government's renewable energy targets without new geothermal plant. Only about 10% of New Zealand's potential has been developed. Delays and uncertainties in the resource consent process, and subsequent compliance costs, have been identified as the biggest obstacle to investment.

New Zealand is unusual in having such a high proportion of hydropower but a high dependence on river inflows because of limited water storage capacity. Dry years reduce hydro generation by up to 40%. Whilst there is considerable undeveloped hydropower generation capacity that has the potential to be exploited, much of this capacity is itself prone to dry year conditions. Most of this capacity could potentially generate electricity at a lower total cost than wind power and other renewables, but for a range of reasons, New Zealand must thus anticipate a decreasing contribution from hydro power over the long term.

'New renewables' such as wind, solar and biomass can make a useful contribution to generation in New Zealand, although wind and solar power are inherently intermittent and this reduces their value. They also remain higher cost options than other renewable technologies such as hydro and geothermal.

Electricity supply

Whilst electricity is not a primary fuel its importance to the New Zealand economy as a consumer energy source is critical. Of the power stations commissioned in recent years, almost all have been fuelled by natural gas, and gas remains the preferred fuel for new power stations. Recently announced plans for distillate conversions and increased coal use are still seen only as interim measures. The reality is, however, that the declining inventory of gas reserves is affecting investment in new generating plant.

With electricity demand in the immediate future unlikely to shrink while the economy continues to grow, New Zealand is facing increasing risk of generating capacity shortfall and, irrespective of any dry year reserve, by 2010 or thereabouts demand is likely to exceed normal-year generating capacity.

There has been inadequate investment in electricity supply infrastructure. A fragmented and incomplete market is not delivering supply-side solutions. Despite the planned contributions for new renewables, New Zealand will continue to depend on fossil fuels for some considerable time to come because the backbone of its renewable energy supply is hydropower, which is vulnerable to rainfall variation. The depletion of the Maui field will have the effect of reducing most of the base and swing capacity for gas as a thermal feedstock. If additional new gas reserves are not discovered soon, coal or distillates are the only realistic alternatives at a time when the Government is moving to a regime of full cost accounting for environmental costs.

PRIORITISING EFFORT

Current institutional arrangements are not effectively delivering security of energy supply despite accurate targeting of some key issues by Government initiatives. Having progressively shifted the delivery of energy services from a centrally planned and managed system, the nation now depends on a fragmented market to deliver continuously through the necessary transition to an energy future without Maui gas.

As the discussion document outlines, we have yet to arrive at a consistent national approach to meeting this need.

After twenty years of neglect, New Zealand is now once more at a crossroad not dissimilar to where it was in the 1970s. New Zealand needs to think differently about the energy services on which it depends. A more robust route towards assessment of supply and demand is needed that looks at energy sector issues in an interrelated way, rather than dealing with its parts. Only an holistic view will derive the equations for success.

There is no single action available to this country. The nature of New Zealand's resource base, the size of its energy markets, and our patterns of energy use limit the options available to us. We do not have the luxury of another Maui. Our thinking needs to take account of several unique factors in both supply and demand. Industry needs to re-examine its role in the wider New Zealand context. Government needs to rethink how it can facilitate and encourage the necessary investments in critical energy infrastructure.

There are three essential strands to the effort required:

- extending New Zealand's primary resources
- development of a strategic reserve capacity
- long-term investment in alternative solutions.

The analysis set out in the discussion that follows offers three performance measures that if examined, adopted and expanded into an agreed industry strategy would offer a framework for future planning and investment:

- minimum levels for self-sufficiency in primary fuels
- appropriate dry year margins
- acceptable levels of reserve capacity and system reliability.

It is within this framework that the desired transition to renewable energy and a fully sustainable energy future can be plotted.

the current energy situation

THE PLACE OF ENERGY IN THE ECONOMY

New Zealand is an energy-rich country, with electricity and gas the key components of its energy profile. For most people and businesses, access to energy is taken for granted. Both require and expect electricity and transport fuels to be available and to be able to increase or decrease consumption at will. In much of the North Island, natural gas is treated the same way.

These expectations have been conditioned by several decades during which they have been satisfied in full, with some exceptions such as the Auckland CBD power failure in 1998 and the power shortages during the 1992, 2001 and 2003 winter droughts. These shortfalls were big news nationally because of the disruption and discomfort associated with the unexpected constraint on a fundamental input to daily life and commerce.

Behind the delivery of energy services lie decades of very large capital investment in generation, transmission and distribution of electricity, and the discovery, development, production and distribution of gas. The two commodities are now inextricably related. About a quarter of New Zealand's electricity is produced from gas, with gas-fired power stations consuming about 40% of natural gas production. Gas is the preferred fuel for new generating plant, and although coal could also fill this role, no major coal-fired plant has been commissioned since Huntly opened in 1983.

A reasonably priced and reliable energy supply is one of New Zealand's key competitive advantages. The cornerstone of the economy is the production of primary products that require considerable energy to process and transport. Electricity and gas are needed for dairy processing, wood production, and the manufacture of meat products, pulp and paper, aluminium and methanol. Coal, LPG and geothermal energy are also important contributors to the national energy mix.

GDP growth over the last 20 years has averaged 2% per annum, and although New Zealand is still a wealthy country in world terms, this low level of growth has been insufficient to maintain the standards of living that many aspire to. New Zealand's economic performance has simply not kept up with many other countries. Energy demand has also been growing at about 2% annually, and so there is a close coupling between economic growth and energy demand growth. The question we face now as a nation is whether we will be able to continue meeting future energy demand whilst at the same time continuing current modes of energy use.

THE IMPACT OF MAUI

The Maui gas field, discovered in 1969, gave New Zealand a one-off opportunity to change its patterns of energy use and to secure its future energy requirements. The coincidental oil crises during the development of the field in the 1970s catalysed the country to take action that was at the forefront of world thinking and efforts at the time. As a consequence of decisions taken then, self-sufficiency in transport fuels increased from only 8% to 65%, and a gas industry evolved to become a key part of New Zealand's energy sector and industrial infrastructure, including electricity generation. This success was a remarkable achievement that attracted worldwide attention and commendation.

But there has been a downside. The security and flexibility that New Zealand enjoyed as a result has had the counter-effect of diminishing the importance of primary energy supply in peoples' minds. Focus instead shifted towards consumer energy requirements, market governance issues and investment efficiency. In the intervening twenty years, New Zealand has had the benefits of inexpensive energy, without giving thought to the future.

During that time, society has seen significant improvement to living standards and has also developed a strong sense of environmental awareness. Energy policy development has been overshadowed by environmental policy and there has been a growing disconnection within our society between attitudes towards energy supply and the facilitation of projects that inevitably have some environmental impact.

Further development of large hydro power stations has become difficult, the output of existing hydro stations is being reduced through loss of water rights, coal-fired stations are perceived as undesirable, and even the development of renewable energy resources such as geothermal and wind energy is hindered. Deregulation of the energy industry has meant that national planning and investment within the sector has diminished, replaced by a reliance on market mechanisms to create economic signals for investment to ensure continuing supply. The range of new policy measures recently announced by Government still focus only on electricity supply, and not primary fuels.

All the while, Maui gas has unobtrusively supported this somewhat idealistic framework of energy sector development by continuing to supply natural gas in line with market expectations and demand variability. Maui reserves have essentially been used as the reserve energy capacity for New Zealand because of oversupply, relative ease of variable production to meet changing demand and a steadily declining sale price in real terms, the product of an ill-conceived escalation provision in a 30-year contract.

As a consequence, necessary investments in alternative energy forms have not taken place and strategies to reduce wasteful use of energy have languished. Critical investment in further delineation of primary energy sources and expansion of strategic energy reserve capacity have simply not occurred. Even though the decisions taken during Maui development anticipated such investment and ongoing energy planning, in the absence of a well-informed market, the opportunity that Maui gas offered has disappeared.

The redetermination of the Maui gas field announced in February 2003 significantly reduced the original gas quantities on which sales contracts were based, and deliveries of Maui gas were constrained. The uncertainty surrounding Maui gas reserves had already had the impact of seeing new electricity generation proposed for Stratford and Otahuhu put on hold. Quite suddenly, New Zealand is now beginning to realise that natural gas can no longer be relied on as an unencumbered resource.

Maui gas was, for the size of the New Zealand economy, a huge resource but could not have been developed without commitment to firm gas delivery contracts. The Maui take-or-pay agreements enabled development of the field but, in the intervening years, new discoveries have not kept pace with the country's increasing consumption of natural gas. There has been little appetite for exploration and even less for development because of the perceived abundance of Maui gas and increasing commercial unsustainability of its price. Maui has been the main contributor to a false sense of energy security, leading to a situation where New Zealand now has limited options without a major rethinking of industry structures and institutional arrangements for primary energy supply.

POST-MAUI TRANSITION

The New Zealand energy sector is rapidly entering a period of transition. This transition will be characterised by uncertain supply, higher costs, and a loss of flexibility and reliability. There may be willingness by some to accept a transformation in energy price, which is being forced on the consumer in any case by factors that are independent of resource availability (such as carbon emissions), but there is unlikely to be a willingness to accept a threat to supply. In particular, gas supplies to the electricity industry will be tight and major gas users will have to consider alternatives. Options for enhancing energy supplies need to be examined and strategies for action agreed.

The impacts of the transition period depend heavily on timely development of the Pohokura and Kupe fields, both of which carry elements of risk, and its duration will depend heavily on the discovery and development of new gas fields. This is how dependent New Zealand has become on gas. The readily available indigenous alternatives to gas-fired electricity generation are coal, geothermal or hydro power. Constraints to the development of these resources place New Zealand's future primary energy supply in jeopardy. Other forms of energy will be simply unable to meet demand unless supplemented by imports.

New Zealand is at a crossroad and is facing a situation where, unless there is major investment in the energy supply system, there is a high risk of continuing electricity shortages. Following the redetermination of the Maui gas reserves, there is now no longer enough gas to supply thermal power stations in a dry year or to fuel new generating plant to meet growth. There has been insufficient investment in alternative forms of electricity generation and the development of reserve capacity. There is an emerging exposure to greater reliance on imported fuels including oil, LPG and coal.

These are significant risks to the New Zealand economy. Investment in the processing industries, which underpin the economy, is exposed. Shut down of major gas-based industries and postponement of new power plants (the latter has already occurred) become major disincentives to investors in these industries, and there is growing evidence that these risks are already impacting investment decisions. If the energy markets contract, incentives for gas exploration also decline and energy supply options will contract further – leaving New Zealand further exposed to economic downturn and the vagaries of global energy markets.

The causes of the problems are complex, and no single action will solve them. It is not simply a matter of reducing energy use, or burning more fossil fuels, or turning instantly to the 'holy grail' of renewables. Current energy management regimes assume functional markets, but it is clear that the markets are not responding by producing the right signals. A programme of solutions is required, particularly to instigate a change in investment patterns, to move towards more sustainable ways of consuming energy, and to persuade our society that some trade-offs will be required to maintain, let alone improve, New Zealand's security of energy supply and economic performance.

The commentary that follows seeks to outline the issues and to inform New Zealanders of their future choices. We examine New Zealand's energy profile, how the energy market operates, the options the country has for energy supply, and then draw together conclusions as to the likely factors that will determine future outcomes.

Finally, and on the basis of this analysis, we suggest a strategy to better manage the risk of supply shortfalls so as to enable this country's full transition to a sustainable energy future.

RISKS AND VULNERABILITIES

The key energy sector issues facing New Zealand can be summarised as:

- The economy is highly vulnerable to power shortages. With electricity demand in the immediate future unlikely to shrink while the economy continues to grow, New Zealand is facing increasing risk of generating capacity shortfall in a dry year. By 2010, or thereabouts, demand is likely to exceed normal-year generating capacity.
- As generating systems run close to capacity, there is a higher risk of interruption of supply as a result of technical or system failure. There is thus in the medium term a plausible potential for significant economic cost and lost opportunity from production curtailment across the manufacturing and service sectors.
- Electricity supply risk is causing loss of investment in new manufacturing or industrial plant in New Zealand.
- A fragmented and incompletely-developed governance framework is not delivering supply-side solutions for electricity. The current wholesale electricity market arrangements are not addressing sufficient security of supply. Participants are reactive, not proactive, and there has been inadequate investment in the electricity transmission network.
- Current proposals for reserve generation capacity remain untested, and until design details are finalised burdens of fuel supply risk and long-term investment remain.
- The replacement of gas reserves is critical to managing the transition phase of the energy sector away from Maui gas surpluses. Gas reserves are not being replaced at their rate of consumption due to inadequate levels of exploration investment. Lead times from discovery to

development are at least four years. In addition to inventory issues, there are supply risks from contractual issues and the reservoir performance of individual fields.

- Failure to secure sufficient gas reserves to maintain at least partial methanol production in this country, at least in the medium term, will leave the New Zealand gas market vulnerable to further market volatility and reduce the incentive for further gas exploration.
- New Zealand exploration opportunities are heavily skewed towards the high-risk, high-capital end of global opportunities.
- New Zealand will continue to depend on fossil fuels for some considerable time to come because the backbone of its renewable energy supply is hydropower, which is vulnerable to rainfall variation. As a result, the New Zealand electricity system relies upon thermal plant for base-load capacity in dry periods. The depletion of the Maui field will have the effect of reducing most of the base and swing capacity for gas as a thermal feedstock.
- If additional new gas reserves are not discovered soon, coal or distillates are the only realistic fossil fuel alternatives. New coal mines could be developed but need a stable market environment to proceed. GHG responses and the time required for consenting processes do not foster certainty, adding to the barriers of developing new coal mines and consequent exposure to reliance on imports.
- The market share of consumer energy provided by renewables has declined. Even though 10-20 PJ of new renewable energy supply is predicted within the next decade, the renewables share of total consumer energy is expected to decline even further. A decreasing contribution from hydro power can be anticipated over the long term. The contribution from geothermal power will be critical.
- Whilst there is significant potential for wind energy, Government estimates are at the high end of what is deemed likely. The value of wind energy becomes significantly discounted as penetration exceeds 10% of demand through electricity system constraints and reliability factors.
- Further penetration of DG technologies will be dependent on changes to the current electricity market and industry structure. Investment in this area will be driven by multi-party capacity and access arrangements.
- There are substantial barriers to development of new hydro, geothermal and wind projects under the RMA even though the Government is encouraging more renewable generating capacity. Projects commonly face 1-2 years of carrying financial risk because of delays in consenting and environment court procedures.
- Behind the delivery of energy services lies very large capital investment in infrastructure. On balance, New Zealand's indigenous energy resources are located considerable distances from our load centres. New investments in supply and distribution networks will need to take account of these changing dynamics.
- Tension exists. Our society demands a high level of environmental protection and clean power supply technologies, both of which increase the cost of energy. But consumers also want the economic advantages of cheap power and reliable supply. Such divergent expectations indicate insufficient understanding of the relationship between resource availability and price.

our need for energy — the demand equation

NEW ZEALAND'S ENERGY PROFILE

New Zealand's energy sector has experience a period of significant change and reform since the 1980s and development of the Maui gas field. The introduction of Maui gas into the New Zealand fuels mix signalled a radical repositioning of natural gas as New Zealand's primary fuel source for thermal power generation and allowed significant substitution of foreign oil in the domestic fuels market. But while the way the sector operates and the dynamics of the industry itself has changed, the underlying fundamentals of primary energy supply remain the same.

A country must meet its future consumer energy demand in almost all industrial, commercial, transport and household activities through its resource base of indigenous or imported primary energy sources. From this platform, it determines patterns of energy use from the industrial and transport mix within the country, its economic growth, and by individual decision on energy efficiency and conservation.

New Zealand is self-sufficient in all energy forms apart from oil. A complicating factor is that oil supply is currently met almost entirely by imports, even though New Zealand produces about 75 PJ of oil a year. Most indigenous production is exported because of product slate requirements at the Marsden Point refinery. This leaves New Zealand about 30% self-sufficient in liquid hydrocarbons, a proportion which is falling and will do so more rapidly as Maui is depleted (see Figure 6). A shift towards distillates to replace gas and even more severe operation of the refinery to meet improved diesel fuel quality will act to further reduce New Zealand's energy self-sufficiency.

The questions that must be addressed are:

- to what extent can oil and gas from indigenous sources supplement current Maui reserves?
- what likely contribution to primary energy supply can be anticipated from new renewables?
- how might demand for imported fuels be reduced through fuel switching, demand management and the uptake of distributed generation technologies?

The answers are dependent, among other factors, on patterns of energy use.

New Zealand's primary energy supply is roughly 760 PJ per year (Figure 1). Consumer energy demand around 460 PJ (Figure 2), dominated by domestic transport which accounts for 41% of consumer demand. The industrial sector consumes 33%, while the agriculture sector at 4.3% consumes even less than the residential sector at 13%.

A range of energy forms (Figure 3) meet this demand, of which 47% are oil products. Electricity supplies another 27% of total consumer energy. Gas now provides 7.8% of consumer energy for direct use, as well as 30% of electricity generation, underlining its importance throughout the whole energy supply chain. Even though it is New Zealand's main fossil fuel resource, coal contributes less than 9% of consumer energy.

OIL

As for any developed economy, the importance of oil to New Zealand can hardly be overstated, with oil products accounting for nearly half of New Zealand's total consumer energy demand.

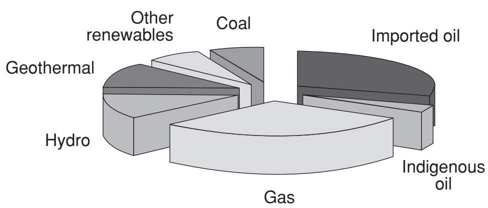

Figure 1: Primary energy supply

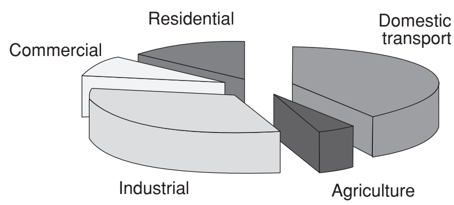

Figure 2: Total consumer energy by sector

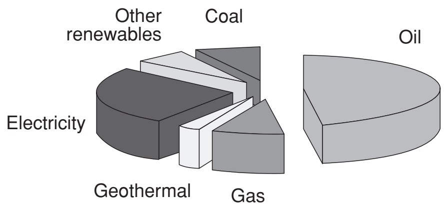

Figure 3: Total consumer energy by fuel

The transport of primary commodities from source to processing point to distribution point, as well as ready access of communities to various transport modes, are prerequisites for economic performance. Ongoing reliance on liquid fuels for transportation and an increasingly volatile world mean that New Zealand supply is becoming increasingly vulnerable to the vagaries of the global oil market as its own gas condensate and oil inventories continue to decline. The strong projected growth in land transport energy demand and increasing contribution of diesel to the fuels mix will exacerbate this dependence.

New Zealand's self-sufficiency in oil will plummet to low levels and continue to fall unless undeveloped offshore oil fields are put into production, and exploration and field development activity increases.

GAS

There is substantial value-benefit to the New Zealand economy from the ongoing development of a sustainable gas industry. Over the last few years, gas consumption (excluding methanol manufacture) has grown at a compound rate of 6% a year. About 40% (47.8% in the March 2001/2002 dry year) of natural gas produced is used for electricity generation, contributing to 30% of electricity supply. Another 42% is directed to the petrochemical industry, almost all for methanol production. Reticulated gas for industrial and domestic consumers accounts for the remaining 18% of gas use. Maui gas currently contributes 75% of this consumption but will not be able to do so from now on.

Methanol production world-wide is typically based on natural gas feedstock surplus to other needs. In New Zealand, methanol production arose as a consequence of the size of the Maui field and New Zealand's commitment to the take-or-pay contract to support development of the field. With the redetermination of Maui gas reserves, and the consequent reduction of gas entitlements to Methanex, it can be anticipated that the company will withdraw from New Zealand in the near term unless it can secure sufficient gas to maintain production from at least one of its methanol processing plants in Taranaki. Continuing methanol manufacture will thus be very dependent on the resolution of contractual rights under the Maui agreements as well as future gas exploration success.

The Methanex plants in Taranaki provide a base load for gas production that reduces risks to the petroleum companies in respect of future exploration and in the management of gas deliveries from current discoveries. It must be recognised that current exploration in New Zealand is primarily seeking oil targets. Without base-load demand, including the gas market that the methanol plants create, there are reduced incentives for exploration. This will eventually translate to insufficient discoveries of reserves for power generation and direct use.

Methanol manufacture also makes a substantial contribution to the New Zealand economy. Methanol exports are worth $900 million annually, and $35 to $40 million are paid to the Government each year in energy resource levies. Value added from Methanex's operation is estimated at $482 million per annum while gross output is about $1.4 billion per annum. The business also contributes over 600 full-time equivalent jobs in New Zealand as well as downstream benefits for a wide range of support industries in Taranaki[1].

In some ways, this example is part of the sustainability dilemma. Gas reserves will not sustain methanol production indefinitely, and the short view is that New Zealand would be better off without this demand on reserves. However, their economic value to New Zealand and influence that the gas market the methanol plants create has on exploration investment means that the medium-term view cannot be dismissed.

Options need to be examined by which New

1 Venture Taranaki/BERL 2002

Zealand might maintain a gas supply sufficient for these facilities, at least in the medium term. Important considerations will include how to manage the residual gas quantities available from Maui to best national advantage, rather than to meeting immediate contractual aspirations, the opportunities for supplemental gas supply from the importation of LNG or LPG, or even the viability of coal gasification or other synthesis gas routes to maintain a viable methanol production capability in this country.

On its own, the current electricity market for gas does not have the required demand characteristics to maintain a viable gas production regime without significant changes to the ways in which the electricity industry operates its thermal plant. Alternatives to the present market structure are needed that are based on secure long-term contracts for base-load thermal capacity struck at sustainable market prices. New Zealand will otherwise continue down its current path of investment in thermal peaking plant, leaving it more exposed to dry-year conditions and the technical risks of gas supply disruption.

In the medium to longer term, such market changes would potentially allow the development of the Kupe field and encourage further generation investment in large, efficient, combined-cycle gas plant — a preferred technical option over the lower efficiency combustion turbine — or integrated coal gasification combined-cycle plant. The current Huntly and New Plymouth plants are very wasteful of gas compared with advanced modern plants such as the Taranaki combined cycle station.

COAL

Coal production in New Zealand for 2002 was 4.4 million tonnes, of which about 2 million tonnes are exported. Domestic use is dominated by two industrial customers. The largest is New Zealand Steel, consuming about 30% of domestic coal supply, with electricity generation consuming about another 20%, although this is subject to considerable variability. The absence of a natural gas supply in the South Island has led to widespread and growing industrial use of coal in the south.

Almost all of the 500,000 tonnes of coal used for electricity generation is burnt at the 1000 MW Huntly power station. Because other major coal consumers have a generally steady coal consumption pattern, the variability in domestic consumption is largely a factor of the amount of coal utilised at Huntly in any year. This variability may continue to be significant up to the final depletion of Maui gas, as Genesis Power's fuel strategy at Huntly power station is to access discrete parcels of gas and increase coal consumption as gas prices increase. This equation demonstrates the significance of the Huntly station to the New Zealand energy sector.

If there are no further discoveries of gas, or there are delays in bringing undeveloped discoveries into production, the contribution of coal to New Zealand primary fuels mix will have to increase significantly. However, uncertainty of future needs in a disaggregated market, and the potential for delays in new coal mine development for this and other reasons, may require shortfalls to be met by coal imports as has occurred in 2003.

ELECTRICITY

Electricity contributes 27% of New Zealand's consumer energy requirements of about 460 PJ. Although it has a natural technical monopoly in some applications, electricity must compete with gas, LPG, coal and oil products in many industrial, commercial and household applications, both at grid-connected and isolated sites. This is particularly the case where fuel is used directly for heating and industrial processes.

Electricity demand is increasing at around 2% per annum (about 800 GWh per annum), requiring over 150 MW of new generation capacity on average each year. The 2002 review of electricity supply and demand (by Sinclair Knight Merz in association with CAE) indicated that by 2003, there was a likelihood of serious shortages during a one in 15 year dry year, and by 2006 almost any reduction from normal year hydro generation capacity would result in electricity shortages. By 2010, unless there is a change in current generation investment levels and patterns of energy use, there will not be sufficient generation capacity to meet normal-year requirements (Figure 4).

During the six months since the 2002 review, New Zealand has been reminded of its key message: that new electricity generation capacity needs to be built soon to ensure ongoing security of supply.

The new Electricity Commission is intended to secure adequate reserve capacity to meet future dry year requirements, recovering the cost of reserve generation via a consumer levy. While this is an important step towards managing electricity supply security, significant investment in new generation is still required to meet normal demand growth.

Demand side management

During the transition from Maui gas to other energy forms, the primary energy focus needs to be on the electricity industry as there needs to be an overall reduction of demand in order to maintain system security during times of electricity shortage. This can be done indirectly through pricing or directly through energy conservation. Recent market behaviour suggests that the price of electricity has to go up by a factor of five or ten before there is a noticeable reduction in use, because the value of electricity is much higher than its price. Even then, response is limited to users with tariffs and metering arrangements that expose them directly to pricing signals. Domestic and small commercial consumers have essentially been insulated from these influences, with the burden falling mostly on major electricity users.

Demand-side management through energy conservation or load shedding requires industry participation. EECA estimates are that industry participation in demand-side management by shifting loads from peak periods or voluntary restraint can achieve long-term reductions in demand of as much as of 400 MW, with added benefits of improved market efficiency and price stability.

The viability of such measures, however, is open to debate. A concerted national voluntary restraint effort by the general public, industry and commerce in 2001 produced short-term savings in the region of 10% to 15%, but with considerable sacrifice by New Zealand consumers. In 2003, short-term savings produced savings of up to 10%.

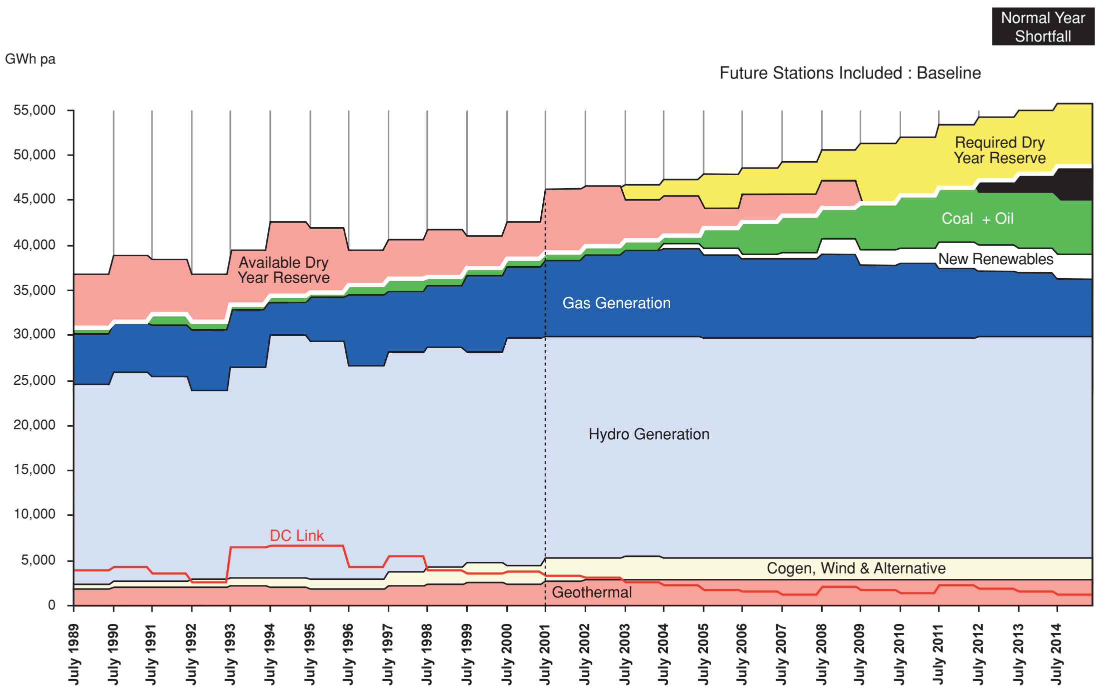

Figure 4: New Zealand electricity generation 1989-2015 in a normal year, with extra generation required to meet load growth from 2009/10. A steady increase of gas-fired generation peaks at about 10,000 GWh in 2005/6 before it steadily drops off as Maui gas runs out. By 2015, either 4000 GWh of new generation will be required or about 15 PJ per annum of gas will need to be found for the gas-fired stations. Source: Electricity supply and demand to 2015. Sixth Edition, October 2002, CAE.

Proponents of large-scale demand side management as it is currently applied in New Zealand implicitly assume that many productive businesses and industries would be prepared to shut down to reduce power costs during a drought period. This implies a belief that the cost to the country of the loss production is less than the cost of providing reserve capacity to mitigate the effect of supply shortfalls. There is emerging evidence that investment decisions in manufacturing plant are being deferred or transferred to other countries because of electricity supply risk.

Although many industrial customers have a part or all of their electricity demand exposed to spot prices, market arrangements are based on export prices (i.e. the price is only known after the event), and these customers face the uncertainty of high electricity prices based often on incomplete information. Until the electricity market moves to *ex-ante* pricing (i.e. when the price is set ahead of the period to which it applies), industry will not be able to fully manage its energy cost risks.

In any discussion of demand side management, there must be a clear understanding of the difference between load shifting and load shedding. Control of hot water heating has been a demand-side management tool in the New Zealand electricity for more than fifty years, although as a result of the electricity market reforms it is being used less effectively than before. This approach shifts load from peak demand periods to off-peak periods with a reduction in overall peak demand, but leads to no change in the total amount of energy used. Equally, demand-side energy exchanges will not release new capacity into the market to meet demand growth.

ENERGY EFFICIENCY

Government initiatives to improve energy efficiency have set a target of an economy-wide improvement of at least 20% by 2012. Implementation will come from avoiding waste, improving technical efficiency, and adoption of renewable energy strategies. The latter is especially desirable if fossil fuel consumption is reduced as a result.

This target equates to an annual improvement of 1 to 1.5% efficiency above an anticipated natural rate of improvement in energy efficiency of 0.5 to 1% per year. CAE studies in 1999 of the potential for energy savings in the New Zealand economy suggest a more conservative view. The target set by Government should be seen as being at the upper end of what is most likely to be cost-effectively achievable, but the risks of not meeting these targets are significant.

The CAE work focussed on four broad sector groups: energy production; the transport sector; the communities and household sector; and the industrial and commercial sector. All of these groupings characteristically have a high inertia of resistance to change largely due to long-lived physical structures and long-term investment cycles. The capital costs and lifetimes of existing infrastructure thus dominate decision making in respect of energy efficiency. Combined with this, economic growth, improved standards of living and lifestyle choices continue to place upward pressure on overall energy consumption.

Analysis of the possible impact of key changes in each sector indicated that quite aggressive energy efficiency measures will be required if New Zealand is to significantly improve its overall efficiency rates to the level aimed for by Government. CAE projections are that New Zealand is more likely to see improvements in energy efficiency of around 12–15% rather than the 20% envisaged by Government.

Within the industrial and commercial sectors, government programmes to encourage retrofitting of existing building stocks and plant will be necessary. Improved energy management systems and the introduction of new process technology and closed loop processing will also be important contributors. At the household level the greatest potential for energy efficiency savings will be through the introduction of new building design standards and the encouragement of passive energy systems.

The transport sector was identified by CAE as the most critical in terms of further study and finding innovative solutions. Unless progress is made in this sector, the opportunity for economy-wide improvement will be lost. The immutable fact is that, without substantial and fundamental changes to New Zealander's attitudes to energy use, changes to market structures and government intervention measures, the prospects of significantly reducing energy consumption through demand-side management are constrained.

As important, therefore, as improving overall energy efficiency is the identification of opportunities for New Zealand to modify its energy mix to meet future needs. The real path we must follow is to make our future energy supply/demand chain more efficient.

what do we have — NZ's energy resources and the supply equation

New Zealand must maintain an efficient energy sector and security of supply during and beyond the transition phase that has now begun with the decline of the Maui gas field. The close historic coupling between economic growth and energy consumption means that meeting the Government's economic growth target of 4% each year will require a commensurate expansion of New Zealand's energy supply in spite of efficiency gains.

About 30% of New Zealand's energy consumption and 70% of electricity comes from renewable sources. This is very high by international standards[2] but is declining, particularly because of the currently favourable economics of combined cycle gas technology for electricity generation and the increasing contribution of transportation to total energy demand. The question that thus arises is how New Zealand might act to meet projected future growth in energy demand, particularly for electricity generation. The likely contributions from available energy sources are discussed in the sections that follow.

OIL

All of New Zealand's producing oil and gas fields and reserves are in the Taranaki Basin (Figure 5). Discovered oil/condensate reserves total 2150 PJ, of which 435 PJ remain. Of the remaining reserves, 240 PJ are in the Maui field (original liquid reserves of 1150 PJ). There are significant additional reserves in the undeveloped offshore Maari and Kupe fields[3]. Other oil fields are either very small, nearly depleted, or both.

New Zealand produced 65 PJ of liquid hydrocarbons in the year to September 2002, down from 74 PJ the year before and from a peak of 120 PJ in 1997. Current crude oil, condensate and naphtha production comes from nine onshore and offshore oil/gas fields, all located in Taranaki. Maui is the dominant source, supplying about 75% of total oil production.

The New Zealand Refining Company Limited operates the only oil refinery in New Zealand at Marsden Point near Whangarei. The refinery processes some local, but mainly imported crude, condensate and blendstock to produce a full range of refined products for distribution by the major oil companies. Most of indigenous production is exported, so that domestic oil demand is thus met almost entirely by imports. Oil imports included 216 PJ of crude and 18 PJ of blendstock for refinery feedstock in the year ended September 2002. Unlike locally produced natural gas supplies, New Zealand-produced oil products are priced at prevailing international rates.

Over the period 1974 to 1986, New Zealand's net oil self-sufficiency increased from under 5% to over 85% commensurate with development of the Maui gas field, synfuel production from Motonui, and exploration successes, almost all by the then Government-owned Petrocorp. Together, these achieved near self-sufficiency of oil in New Zealand at a time when it was not

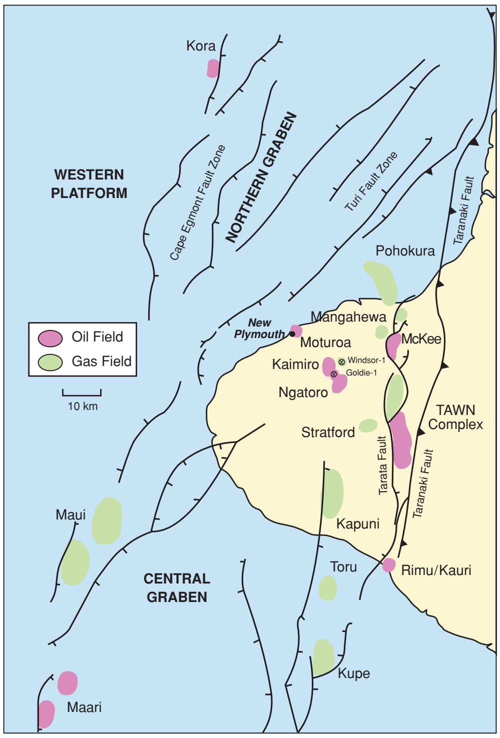

Figure 5: Oil and gas fields, Taranaki Basin

2 Comparative figures for electricity generation are Australia 3%, United Kingdom 3%.

3 Pohokura and rimu figures are not included because of their uncertainty.

highly valued. Because demand increased faster than production, this figure had declined to 31% by the year ended September 2002 and will decline much further when Maui production comes to an end.

New Zealand has considerable geological potential for improving its net self-sufficiency in oil. In fact, geological fundamentals indicate potential for New Zealand discoveries to create a surplus of hydrocarbons again, but only subject to much higher levels of exploration investment.

Current successes are mainly in small low risk/ moderate reward onshore targets rather than the high risk/high reward targets that have the potential to make a significant improvement to New Zealand's self-sufficiency. These bigger targets are mainly offshore, with much higher exploration costs.

The alternative to increased exploration effort is growing exposure to global oil markets. The OPEC-driven oil shocks of the 1970s and the need to mitigate the Government's liability under the Maui Gas Contract gave rise to 'Think Big' as New Zealand, like all consuming nations, responded to the need to improve security of supply. The two decades since has seen a weakened OPEC balanced by North Sea, Alaska and other non-OPEC suppliers. The global pendulum is now swinging back to dominance of supply from the Middle East, at a time of great instability in the region and rapidly declining self-sufficiency in New Zealand. There are now plausible scenarios for New Zealand being deprived of oil imports, which coupled with dwindling indigenous reserves, would be disastrous for the economy.

GAS

Discovered gas reserves as at January 2002 totalled 5600 PJ, of which 1700 PJ remain. Of the remaining reserves, 750 PJ are in the Maui field which had original gas reserves of 3748 PJ. Pohokura gas reserves are uncertain.

Over a period of only 30 years, natural gas has become a cornerstone of the New Zealand energy sector, in both the tactical and strategic senses. The rapid ascendancy of the importance of gas has been driven by exploitation of the Maui field, currently supplying 80% of demand. But an adequate level of strategic reserves has not been maintained, and New Zealand now faces gas supply difficulties (Figure 7).

In the short to medium term, the replacement of gas reserves is a key option in managing the transition from Maui gas surpluses to a gas-constrained market. A reliable gas supply for electricity generation would allow more efficient responses to dry-year generation risk and to meet incremental demand growth above the contributions expected from distributed

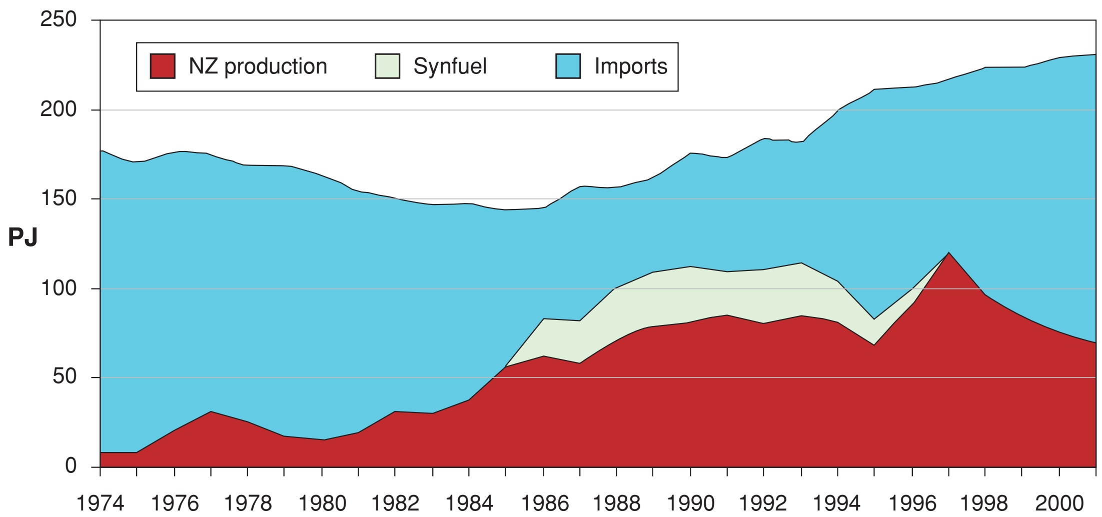

Figure 6: Net oil imports and New Zealand oil production (crude and condensate) 1974-2001, showing fluctuation in oil self-sufficiency. Data compiled from Energy Data File 2003, Statistics New Zealand, and commercial sources.

generation, reserve generation capacity and energy conservation. Without large new discoveries, there will not be sufficient gas for continuing petrochemical production in New Zealand and there will be ongoing constraints in electricity supply.

Depending on exploration investment and successes, future gas supply could be:

- reduced to well below demand, with only trivial additions to reserves
- sufficient to meet demand, but with tight supply aggregated from a number of small fields
- surplus to requirements, if large discoveries are made .

The current most likely prognosis is that future supply will come from a number of smaller fields than Maui. Maui has been able to act as a shock absorber for demand swings because the Maui Gas Contract is based on a 'take-or-pay' arrangement, and large quantities of pre-paid gas can accrue to the buyer. At one stage, Maui had built up 300 PJ of pre-paid gas worth NZ$600 million at today's prices. Entitlements to these prepaid gas quantities have been subject to long-term supply arrangements via the government as owner.

The redetermination of Maui reserves could compromise the delivery of the current balance of pre-paid gas. The role of the government in determining the final outcome will be vital. The nation may benefit more by Government agreeing to daily and yearly delivery profiles from the gas field to encourage better risk management strategies over the next several years, rather than seeking simply to make the most of its pre-paid gas.

Post-Maui gas supply will require market arrangements that allow more complex juggling of supply and demand without the long-term supply contracts that have so far characterised the New Zealand market. In this transition, the massive swing capacity so far provided by Maui will disappear. Therefore, changes in gas market dynamics will be as important as changes in supply. Related to this transition from the dominance of Maui gas is the need for access to the Maui pipeline for non-Maui gas.

Gas exploration

New Zealand's gas inventory is declining because there has been inadequate investment in exploration to replace the reserves being consumed. This has been known by the exploration and production industry for several years, but there have been significant barriers

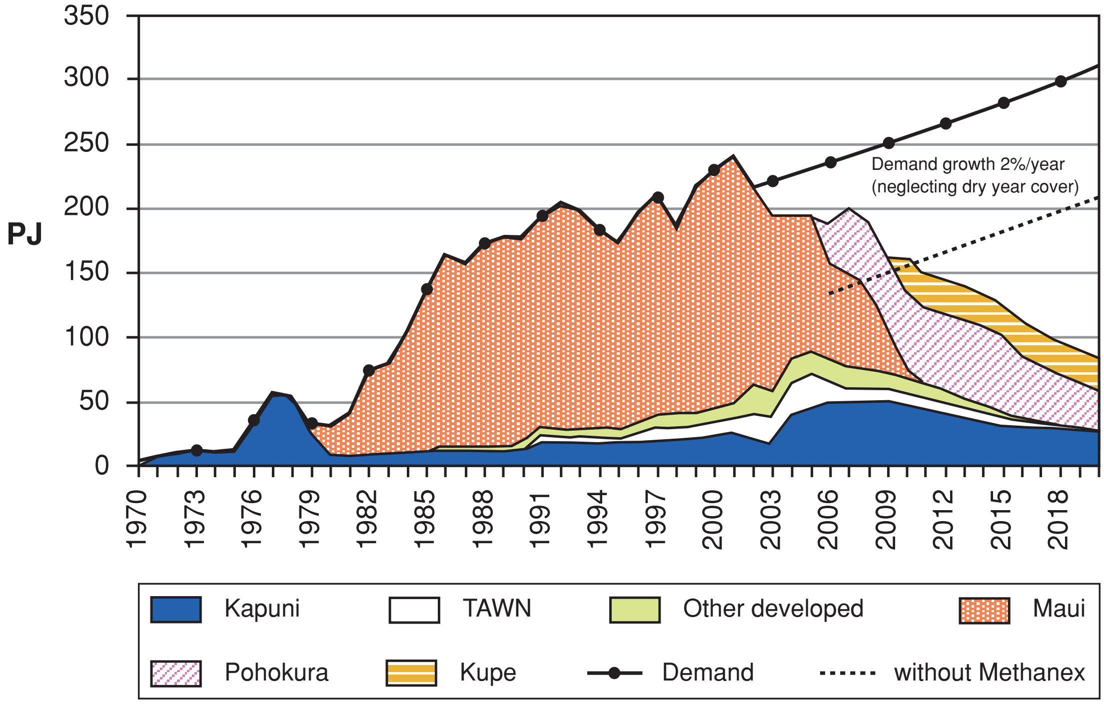

Figure 7: Gas supply and projected demand, 1970-2020. Source: GeoSphere

to attracting the level of exploration required. It is quite common for developed countries to have a gas inventory of 10 to 12 years[4], maintained by appropriate levels of exploration.

In addition to the influence of a single, very large field, there are other reasons for the relatively low levels of exploration activity. Hydrocarbon exploration is expensive and carries high risk, and gas has seldom been a primary drilling target since the Maui discovery. Of the 41 applicants for exploration permits in the 2002 Taranaki Blocks offer by Crown Minerals, only two explorers were seeking gas targets. Explorers are disinterested in building up gas inventories unless there is an identified market. The Maui gas price has set the market and has not been high enough to make exploration for gas alone to be sufficiently attractive, and has thus been a key disincentive for explorers. However, at about US$3/GJ, gas becomes as attractive as oil. In contrast, the current price of Maui gas is about one quarter of this.

New Zealand's isolation and small economy are also significant barriers in attracting investment funds in a highly competitive global market. This is reflected in a drilling density for New Zealand that is about 2% that of the United States. Although Crown Minerals of the Ministry of Economic Development puts considerable effort into promoting New Zealand as an exploration destination, the Government has not placed sufficient urgency on securing new gas supplies to intervene in the markets, and New Zealand has effectively lost any ability it might have once had to control its hydrocarbons inventory, exploration effort, and subsequent production. Small discoveries make little difference to the national inventory, and even new fields of moderate size such as Pohokura will not replace the role that Maui has had.

Although recently there has recently been a higher level of exploration permitting activity in New Zealand, this has been dominated by a very few large companies and many smaller niche companies, who are seeking either small oil targets or to develop farm-in opportunities. The smaller exploration companies do not, on their own, have the operational expertise or the financial resources to develop substantial drilling programmes.

These combined factors mean that too few wells have been drilled for gas targets. Exploration effort is strongly skewed towards Taranaki because of its past exploration successes and proximity to downstream infrastructure and markets, but it is a small geographic area for New Zealand to be dependent on for hydrocarbons.

Many discoveries in Taranaki have been gas-condensate discoveries for which there is a huge incentive to monetise gas in order to

4 Australia is currently about 80 years

FIELD	ORIGINAL RESERVES		REMAINING RESERVES	
	Oil/Condensate (mmbls)	Gas (bcf)	Oil/Condensate (mmbls)	Gas (bcf)
Maui	183.7	3452	33.2	592
Kapuni	65.2	1443	5.7	501
McKee	47.4	120	3.4	35
Tariki/Ahuroa	3.2	115	1.0	59
Waihapa/Ngaere	24.3	29	0.4	0.5
Kaimiro	3.3	15	0.8	0.003
Ngatoro	6.4	8.7	2.7	2.2
Mangahewa	0.7	104	0.6	93
Rimu	6.8	39	6.7	38
Pohokura	n/a	n/a	n/p	
Kupe	16.3	264	n/p	
Maari	25.0	-	n/p	
TOTAL	382.1	5590	54.5	1321

Table 1: New Zealand oil and gas reserves as at 30 June 2002 (Source: Crown Minerals 2003). n/a = not available, n/p = field not producing. mmbls = million barrels, bcf = billion cubic feet.

> New Zealand has amply demonstrated the capacity for significant discoveries in the past two years. Its energy markets will clearly absorb significantly more gas than has been discovered and developed to date, and prices significantly above those of the Maui contract can be expected. Unfortunately several factors appear to be impeding the capital investment required to feel assured that an adequate level of effort is being made to realise the opportunities. The attractions to potential new entrants should be obvious.
>
> *Mac Beggs, 2002 New Zealand Petroleum Conference*

obtain liquids revenues. In discoveries that are rich in liquid hydrocarbons, gas revenues become a secondary consideration as development economics will normally be driven by the value of the liquids.

It also needs to be recognised that New Zealand's exploration opportunities are heavily skewed towards the high-risk, high-capital end of global opportunities. Offshore wells cost in the order of NZ$10-30 million each, and a single well in the newly delineated Deepwater Taranaki Basin could cost as much as NZ$100 million.

New Zealand is not short of prospective gas targets, but there are few incentives to explore outside of Taranaki even at expected gas prices, partly because of the huge costs associated with establishing connections to the North Island pipeline network. Onshore Taranaki gas can be bought onstream relatively quickly, but incentives are needed to attract the capital investment required. The pending readjustment of gas markets as a result of Maui depletion should assist that process and is partly reflected in forthcoming drilling programmes, but if Methanex disappears as a major user, a substantial discovery could quickly swamp the relatively small base gas demand.

Coal bed methane is emerging as an exploration play in New Zealand. Even though it is a major fuel source in the United States, the contribution that coal bed methane can make to the New Zealand gas supply equation is uncertain.

COAL

Coal dominates New Zealand's energy inventory and has the potential to contribute a far higher proportion of New Zealand's primary energy supply than it has in the last 40 years of development of hydro power and gas reserves. The current attitudes to coal use need to be balanced against the costs to the economy of not using the country's major known energy source for delivering low-cost electricity. In addition to its relative importance as a fuel supply for electricity generation, coal also could be a viable alternative to gas. In the long term, the cost of coal conversion has the potential to influence the price of other forms of primary energy supply depending on the marginal cost of CO_2 sequestration.

Coal forms a high proportion of the primary energy supply of many countries. Coal currently supplies only 5% of the electricity generated in New Zealand, compared to 80% in Australia, up to 60% in the United States, and 37% worldwide.

Unlike oil and gas, coal deposits can be explored systematically and New Zealand's coal resources are well known through past government-funded exploration. The country has 15 billion tonnes of in-ground coal, of which 8.6 billion is estimated to be economically recoverable.

More than 80% of the total in-ground resource are lignites in Otago and Southland, which have a high moisture content and are distant from the centres of high energy demand. Large sub-bituminous coal deposits in the Waikato are more usefully located. New generating plant could be supplied from Waikato opencast reserves, which include 18 Mt at Maramarua, 45 Mt at Ohinewai, and 35 Mt at Rotowaro. Waikato underground reserves are also substantial but are likely to be expensive to extract or unable to supply at the rate required. There are also 30 Mt of opencastable coal near Mokau in Taranaki. Virtually all of these North Island reserves have been evaluated by mining feasibility studies carried out in the 1980s and constitute New Zealand's most

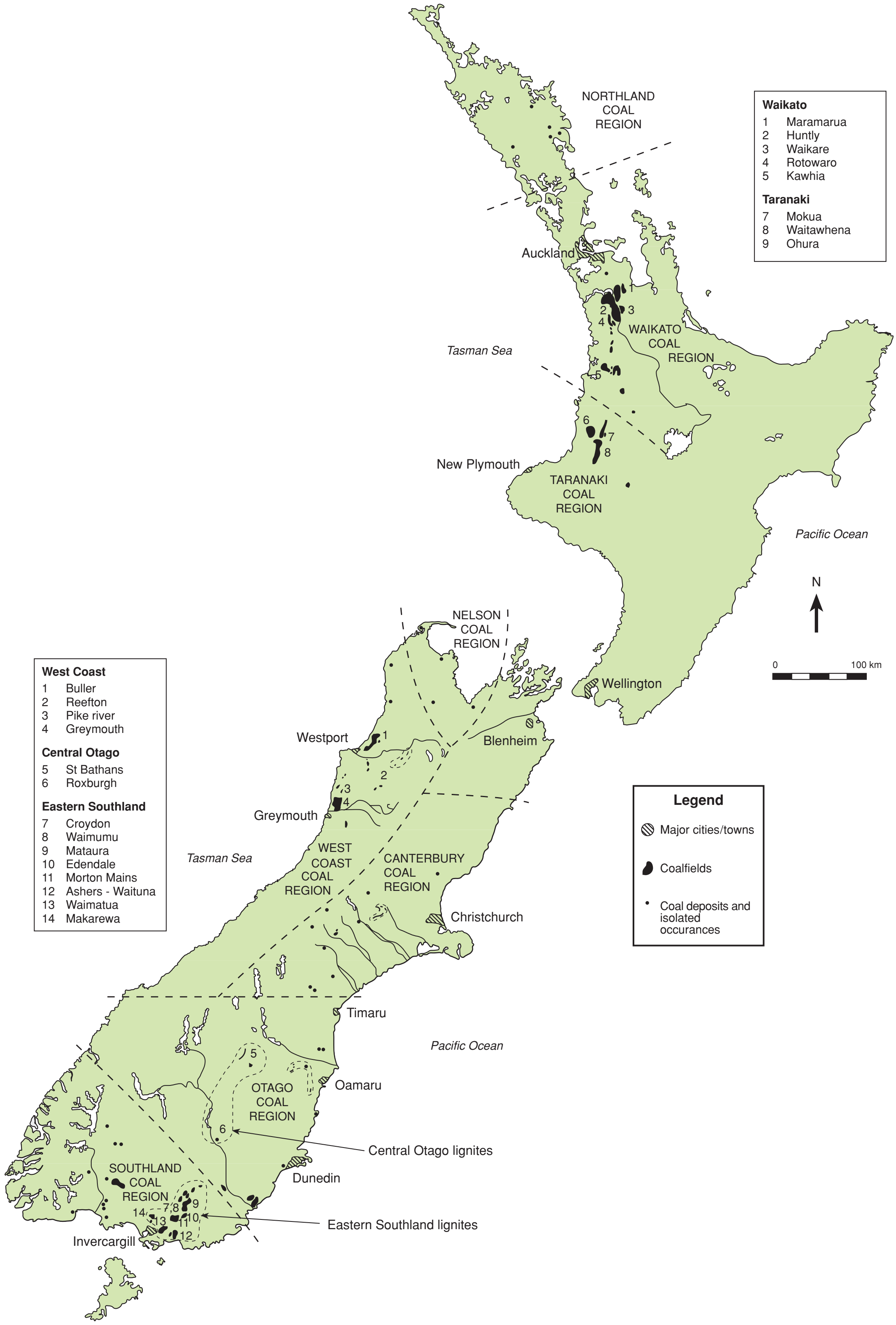

Figure 8. Principal New Zealand coalfields

COAL REGION	RECOVERABLE COAL (MILLION TONNES)
Waikato	714
Taranaki	173
West Coast	343
Canterbury	2
Otago	1154
Southland	6256
Total	8643

Table 2: New Zealand recoverable coal resources. Source: Crown Minerals

strategically important coal resource.

Coal could supply new thermal power stations either as base load or peak load in combined gas/coal fired stations. Although commonly used as a base-load thermal fuel, coal has some advantages as a peak-load fuel because it can be stockpiled. However, there are limits to this flexibility, partly in the context of the scale of coal mining in New Zealand, but especially in the context of the required provisions for forward planning. If coal had been used instead of gas to make up the shortfall during the 2001 hydro shortfall, about 1.5 million tonnes would have been needed. In 2003, coal imports are being used because additional domestic supply is not immediately available.

This level of flexibility is well within domestic coal supply capabilities if requirements can be planned into mine operation and infrastructure development. New Zealand coal can also be competitive with imports if there is a sufficiently certain planning opportunity. Reserve coal was historically maintained at Huntly, both stockpiled and in-ground, for dry-year electricity supply shortfall. Maui gas has performed this role in recent years, but coal could now return to this role of providing a thermal hedge as an alternative to gas.

However, without a rethink of the potential role of coal in the New Zealand energy sector, there are likely to be formidable barriers to the development of new large coal mines, especially in the Waikato. These mines, especially opencasts, face issues of investment capital, long lead times, geotechnical risk, delivered cost, and the obstacles of the resource consent process.

International agreements under the Kyoto protocol now limit CO_2 emissions. CO_2 is emitted at around 53 kg/GJ gross of natural gas combusted, whereas sub-bituminous coal typically emits 91 kg/GJ gross. Carbon taxes will increase the cost of sub-bituminous coal feedstock to a thermal power station by about $52/tonne[5]. Furthermore, burning additional coal at Huntly to offset gas shortages could cost the country between $200 and $500 million of the expected income government anticipates from selling carbon sinks[6].

As a consequence of this charge and uncertainty about the value of investment in carbon offsets, there is now a strong disincentive for development of coal-fired generation plant. Yet the certainty of knowledge about New Zealand's coal resources means that it is arguably the most robust fuel option for long-term security of electricity supply.

Advanced fossil fuel technologies are leading to fundamental changes in thermal power generation world-wide. Maximising efficiency and heat recovery clearly favours gas turbines over conventional steam turbine technology. The addition of gas turbine to existing steam power plant offers advantages from efficiency gains and increased generation capacity. Advanced CO_2 control options are also being actively investigated. Using these approaches, integrated coal gasification combined cycle plant (ICGCC) converts coal firstly into syngas to power a gas turbine, followed by further heat recovery in a steam generator and turbine set.

Movement towards the increasing upgrade of residual or heavy crude oils also reinforce this trend, with new refinery polygeneration projects now emerging based upon pitch or

5 Coal Newsletter, December 2002
6 The Energy File

coke gasification for syngas manufacture. World-wide there is almost 50,000 MW_{th} of commercial gasification activity, mostly as feedstock for syngas chemicals. Low marginal costs for CO_2 capture offers the opportunity for reducing CO_2 emissions to close to zero. There may be opportunity in New Zealand to combine the need for supplementary gas supplies with power generation.

Additional base-load generating capacity is needed in New Zealand, and if coal is to be used, significant economic and environmental advantage derives from large scale centralised plant. In particular, large point sources of power generation enables CO_2 capture. Coal also has an advantage over gas by being available in most New Zealand regions, and a spread of coal-fired thermal generation, together with certainty of supply, has potential for allowing greater flexibility in using hydro resources.

The opportunity for coal to contribute more to New Zealand's primary energy supply needs to be examined. Often overlooked is the suitability, backed by extensive studies in the 1980s, of the South Island lignite resources for gasification and conversion processes.

HYDRO POWER

Hydro power contributes 11.6% of New Zealand's primary energy supply and about 64% of electricity supply. It is the major renewable resource in New Zealand that could meet the increasing demand load in normal years, and has the advantage that it is able to provide the short-term storage and frequency stability which complements the variable nature of wind and solar generation among renewable energy sources.

New Zealand is unusual in having such a high proportion of hydro power but a high dependence on river inflows because of limited water storage capacity. A 1-in-20 dry year reduces hydro generation by up to 20%, and the 1991 drought reduced output by 40%. Another factor is the lack of diversity in electricity demand, with electricity surpluses in summer and shortages in winter. As a result, the New Zealand power system must have thermal plant to meet base-load requirements in dry periods backed by excess fuel supply capacity.

There is considerable undeveloped hydro power generation capacity which has the potential to be exploited relatively easily. Most of this capacity could generate electricity at a lower total cost than wind power and other renewables, but what drives investment in these areas is the reserves capacity market and not the long run marginal cost (LRMC) of electricity.

The general expectation is for LRMC prices to increase to the order of 6c/kWh, almost double the current base load price for electricity, but there is considerable price risk in the absence of sufficient reserves capacity and viable alternatives.

A hydro power-constrained supply system remains vulnerable to major cost escalation over and above international price trends.

In this scenario there are two major opportunities for New Zealand: large-scale hydro incorporated with irrigation schemes, such as the proposed 570 MW Project Aqua, and small-scale hydro projects. Multi-use opportunities such as municipal water storage will be much less. Small-scale hydro potential in New Zealand is estimated at about 1000 MW but making allowance for drought prone areas reduces this to around 350 MW total capacity.

New Zealand can anticipate a decreasing contribution from hydro power over the long term.

GEOTHERMAL ENERGY

The predominant use of geothermal energy is

> 'Currently around 80 PJ of coal is extracted in New Zealand, including coal for export. The projected growth in domestic consumption to 2020 will therefore put very significant pressures on the New Zealand coal industry and its supporting infrastructure. It is unlikely that all this increased demand will be met by New Zealand production, given that significant new mine development would be required, potentially at a higher cost than imports.'
>
> *New Zealand Energy Outlook to 2020, Ministry of Economic Development, February 2000*

in the electricity sector. Overall efficiency for conversion to electricity, however, is about 10% thus requiring a significant source to meet specific demand loads. Direct heat use is much more efficient than electrical generation and is the favoured option where possible, but opportunities are restricted.

Geothermal power has many advantages. It has low greenhouse gas emissions (about 10% of a modern coal-fired plant), and is essentially renewable. Power plants normally run at base load and their average generation is roughly equivalent to operation at full load for more than 90% of the time. New Zealand geothermal power has an average generation output of about 60% but it can be relied upon to deliver 100% power when it is needed during peak demand periods and system emergencies. This inherent reliability and flexibility makes geothermal energy a very valuable component of an electricity supply system.

High-temperature geothermal resources exploitable for electricity generation are almost entirely restricted to the Taupo Volcanic Zone with only one other example known, at Ngawha in Northland. It is very unlikely that any other undiscovered high temperature resources exist outside these areas.

Geothermal energy could make a significant additional contribution to New Zealand's generating capacity, and it will be difficult to meet the Government's renewable energy targets without new geothermal plant. Using only current technology, and ignoring environmental and regulatory constraints, the high-temperature resource capacity is estimated to be about 3600 MW of electrical equivalent or about 75% of New Zealand's current total system demand. Only about 10% of this potential has been developed.

Taking environmental and regulatory constraints into account reduces the potential to 898 MW_e. Of that, 412 MW_e can be utilised in existing plants, and 64 MW_e is the subject of granted but not yet exercised consents. There is another 422 MW_e of new potential generation where there is some expectation that resource consents could be obtained in the foreseeable future. Because of the inability to transport geothermal steam over more than a few tens of kilometres, these opportunities are essentially limited to large-scale centralised power generation.

The constraints on increased geothermal energy usage in New Zealand are principally economic and regulatory, not technical. Delays and uncertainties in the resource consent process, and subsequent compliance costs, have been identified as the biggest obstacle to investment. With greater interest in renewable energy from the Government, the imposition of carbon taxes, depletion of Maui gas, and increasing wholesale power prices, that situation can be expected to change.

A legacy of Government-funded geothermal exploration from the late 1950s to the early 1980s is that there are about 100 unused but potentially productive geothermal wells at Wairakei, Tauhara, Rotokawa, Kawerau, Ngatamariki and Ngawha. Some recent developments have made use of these existing wells, but many other opportunities remain. This legacy may provide the best opportunity for geothermal development in the near future. Government's interest is currently being transferred to Mighty River Power.

Geothermal energy for direct use can be provided at very low cost. Recent data[7] imply costs of 4-6c/kWh for new plant, but in the period 1994-97, four new geothermal plants ranging in size from 10 to 60 MW_e were built in New Zealand, when power prices averaged less than 3c/kWh. While some plants may have been built more for strategic reasons rather than strict economics, the developers also made good use of cost savings such as purchasing existing wells to reduce resource risks and drilling costs, and use of second-hand plant to cut delivery times and costs. Both of those opportunities still remain today. Geothermal energy thus has the potential to set future electricity supply pathways if current development opportunities can be realised.

NEW RENEWABLES

Renewable energy technologies are driven mostly by climate change mitigation, and community moves to adoption of sustainable

7 Availability and costs of renewable sources of energy for generating electricity and heat. Report by East Harbour Management Services to Ministry of Economic Development.

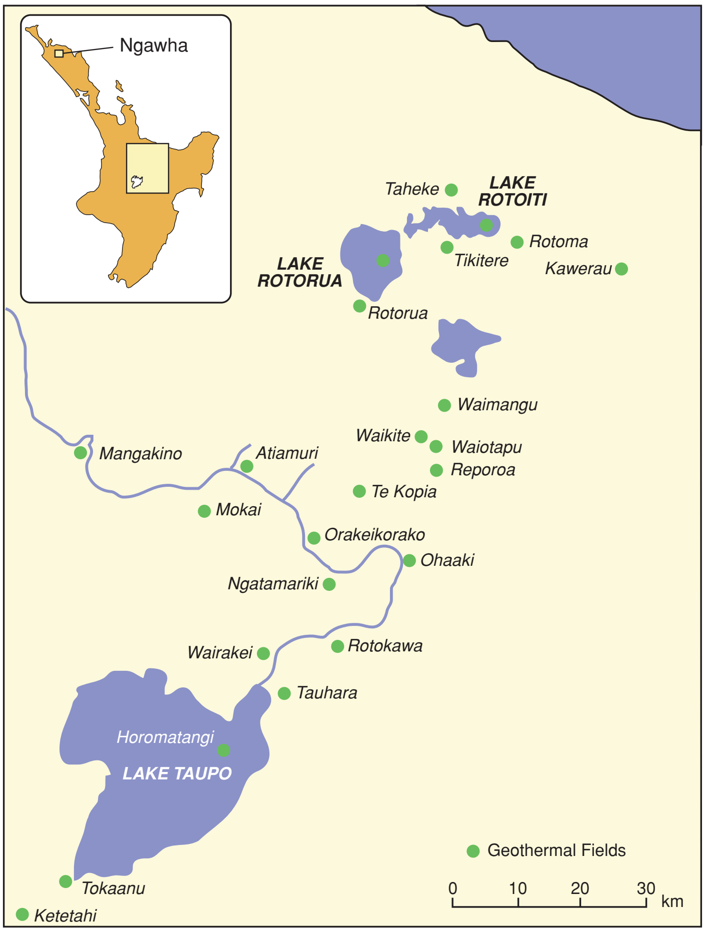

Figure 9: High-temperature geothermal fields

FIELD	MEDIAN GENERATING CAPACITY (MW_e)	INSTALLED CAPACITY	REMAINING CAPACITY LESS CONSTRAINTS*
Atiamuri	6		0
Horohoro	5		5
Kawerau	450	40	95
Ketetahi	100		0
Mangakino	47		0
Mokai	140	65	28
Ngatamariki	120		0
Ngawha	75	10	30
Ohaaki	130	45	0
Orakei-Korako	110		0
Reporoa	42		0
Rotokawa	300	27	171
Rototuma	35		21
Rotorua	35		0
Tauhara	320		0
Te Kopia	96		0
Titikere-Takehe	240		72
Tokaanu	200		0
Waimangu	280		0
Waiotapu	340		0
Wairakei	510	225	0
TOTAL	3581	412	422

Table 3: New Zealand geothermal resources and generating capacity
** Constraints include environmental limitations, regulatory constraints and sustainability conservatism. Source: JV Lawless, Sinclair Knight Merz 2002*

> ‘Recent geothermal projects in New Zealand have been small in comparison both to the size of the resources and to developments overseas, largely because of regulatory constraints. This, in turn has led to dis-economies of scale. The regulatory process leads to long delays which impose a significant up-front cost on the projects, greatly reducing their financial viability.’
>
> *Jim Lawless, President NZ Geothermal Association, 2002*

energy sources. ‘New renewables’ such as wind, solar and biomass can make a useful contribution to generation in New Zealand, although wind and solar power are inherently intermittent and this reduces their value. They also remain higher-cost options over other renewable technologies such as hydro and geothermal.

If wind and solar power are to be exploited, their capacity needs to be backed by flexible operation of hydropower stations, which have the advantage of being able to change load rapidly without incurring high costs. This means that the lake levels and flows down-stream of the stations need to be allowed to change rapidly, but environmental restrictions being placed on hydro stations are reducing their ability to operate optimally. The alternative to hydro flexibility is that water will be spilled and more fossil fuels will need to be burned. Decisions on which option is preferable need to compare the environmental effects of greenhouse gas emissions with damage to catchments.

Wind

Wind energy currently provides approximately 150 GWh per year of electricity, or under 0.5% of New Zealand’s electricity supply. There are two existing wind farms, in the Wairarapa and near Palmerston North, and a single unit at Wellington.

As an intermittent renewable energy resource, wind best fits in a support portfolio because it requires system backup. Wind is useful when it complements hydro storage to some extent: when wind is contributing, less water is required to be released from storage and can be held in reserve for when wind is not contributing.

On average, generation from wind farms in New Zealand will be less than less than 50% of nominal installed capacity. Based on existing New Zealand experience it is likely that a 100 MW wind farm would generate the equivalent of a 45 MW thermal station. In addition, it is not possible to predict how much power a wind farm will generate at any given time. This makes wind generation difficult to schedule and requires a larger amount of reserve capacity than would otherwise be required.

The main barriers to further development of wind energy in New Zealand are economics, partly set by currently low gas prices, resource consent risks, and network connection costs because of location and technical constraints. Up to thirteen general areas have been identified as suitable for potential wind farming (Figure 9), mostly near the coast since coastal winds are generally of a higher average speed and consistency.

At present, wind energy generally costs significantly more than competing forms of electricity generation at a systems level. Whilst indications are that the cost of new wind energy generators is around 6 to 7 c/kWh at the best sites, studies by CAE suggest that at around 10% of the system peak demand, wind generation will need to be $12/MWh cheaper than base-load thermal plant to compete.

EECA has suggested that if economic and resource consent conditions were favourable, New Zealand’s wind resource could provide approximately 23% (7900 GWh per year) of the country’s present electricity needs within 10-15 years at costs of up to 10 c/kWh. This must be regarded as at the upper end of what is possible. At this level of contribution the value of wind energy would be significantly discounted due to system constraints and generation reliability factors. Moreover this level of generation would require construction of nearly 60 wind farms equivalent to the 48-turbine Tararua facility. That is effectively one turbine set being installed and got into operation each working day of the year for the next ten years – a difficult ask.

A more realistic estimate, based on required energy at grid exit points, suggests a potential maximum contribution from wind power with the current system configuration of about 1000MW, or about 4000GWh/y.

Bioenergy

Woody biomass currently provides about 35 PJ or 5% of New Zealand's primary energy supply. The main use is burning waste wood residues to provide heat for the timber industry. About 5 PJ is for residential heating in wood burners and open fires.

There are significant opportunities to increase the use of biomass as an energy source as

Figure 10. New Zealand wind potential

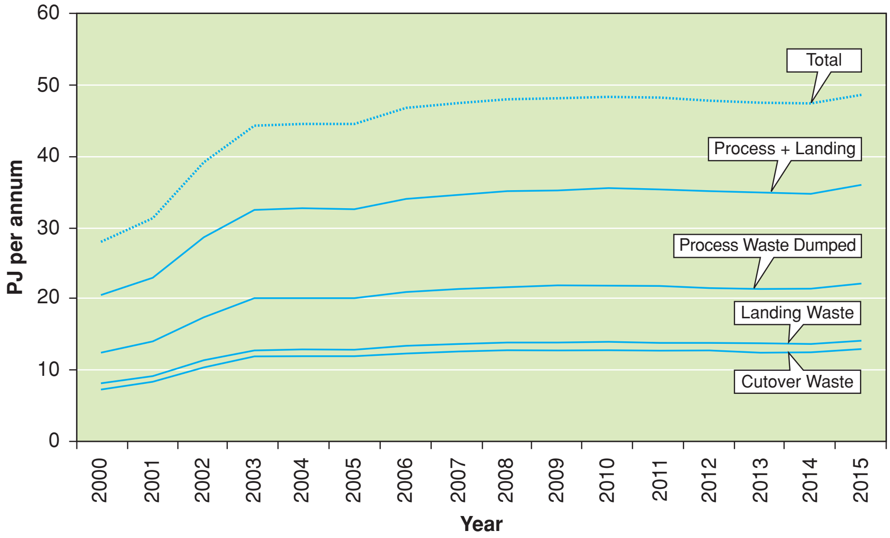

Figure 11: Projected biomass residue volumes by year

approximately 40-50 MW_{th} heat plant capacity is estimated to be required annually to meet industry drying and processing needs. Some of this additional heat demand could be based on co-generation solutions, but it is likely that the predominant use will be for direct heating.

Estimates of the technical potential for woody biomass for New Zealand indicate that by 2005, an additional 50 PJ/year could be available, surplus to industry demand, from increasing volumes of forest harvesting. Total quantities of residues would remain fairly static from then on at about 4.5 million m^3 per year, representing a total contribution of over 10% of consumer energy.

However, while quantities of recoverable wood waste from the New Zealand forest industry are potentially significant, its recovery will require transport distances of up to 100 km.

Work by CAE indicates that delivered costs are likely to be in the range of $3-$4/GJ for material that is around 50% water content. After taking drying into account, costs are likely to be $2/GJ greater than coal.

There are a wide range of potential biomass resources outside of forestry and wood processing. Some of these include municipal green waste, landfill gas, demolition timbers and horticultural wastes. Some regions will have concentrations of these sources that may be amenable to conversion to conventional energy forms, but the total contribution is likely to be small. In the absence of a formal market for waste or residues, there is a substantial commercial risk from supply shortfall and competition for fibre at times of high commodity prices. Guarantees of supply are difficult to obtain, and the technical risk associated with variation in fuel quality also limits harvesting and conversion technology selection.

ELECTRICITY

New electricity generation plant and transmission infrastructure is needed to meet demand growth of about 2% a year and to ensure security of supply in dry years. This is equivalent to over 800 GWh or 2.88 PJ per year, requiring energy inputs as follows.

Hydro power accounted for 65% of New Zealand's current electricity supply of 139 PJ or over 38,000 GWh in the March 2001 year. Gas and geothermal generation accounted for a further 23% and 7% respectively. These shares vary from year to year depending largely on inflows in hydro catchment areas. Coal and other energy sources (consisting mainly of renewables such as wind, biogas, industrial waste and wood as well as co-generation) currently account for only 2-3% of electricity generation.

While Government policy is to give preference to renewables, for a range of reasons outlined previously, gas is the preferred fuel for new power stations, and thus the declining inventory of gas reserves is affecting investment in

ENERGY SOURCE	ANNUAL ENERGY REQUIREMENT TO MEET 2% ELECTRICITY DEMAND GROWTH
gas	22.5 billion cubic feet[1]
coal	380,000 tonnes of sub-bituminous[2]
oil	15 million barrels[2]
geothermal	unconstrained development of an average geothermal field
wind	300 new wind turbines
hydro	a new hydro station equivalent to the Aviemore dam
solar	360,000 domestic solar water heaters

Table 4: Energy supply by commodity or generation type required to meet predicted 800 GWh (2.88 PJ) per annum growth of electricity supply requiring 150 MW of new installed capacity every year. This comparison demonstrates the difficulty of meeting growth requirements from renewable sources and the importance of fossil fuels.[1] assuming efficiency of 50% for CCGT, [2] assuming 33% efficiency for steam turbine plant

new generating plant. Setting aside the dry year reserve problem, there still remains the dominant issue of how New Zealand's electricity system will meet future normal-year demands.

CAE analysis suggests that there is a range of factors influencing the behaviour of the market and its capacity to provide the right signals to ensure future investment and security of electricity supply. These include:

- decision-making processes are not encouraging nor are they initiating investment in the transmission network
- current market does not provide consistent long-term price signals to flag the need for new capacity or encourage demand-side response
- the complex and time consuming approvals process means that embarking on a new generation project is a long-term, high-risk and expensive enterprise
- the fragmentation of the industry is leading to sub-optimal solutions
- customers are reluctant to purchase hedge contracts and prefer to self-insure against spot prices or resort to a 'political hedge'
- levy imposition to support reserve capacity.

Industry dynamics

Until the late 1980s electricity generation in New Zealand was predominantly government owned and centrally planned, with the Committee to Review Power Requirements producing its estimates of future power demand and the Power Planning Committee producing proposals for meeting that demand. Government investment established most of the physical capacity delivering energy to New Zealand homes and businesses today.

Since that time, restructuring of the industry has occurred over a number of stages. Electricity supply is now from as many as 16 generating companies, of which the SOEs Meridian Energy (33% of supply), Mighty River Power (10%) and Genesis Power (14%) and listed company Contact Energy (22%) are the largest.

Electricity transmission is operated by Transpower, another SOE, which connects most of the major power stations to local distribution lines and to the major industrial users according to a sophisticated mix of technical and market instruments that have been adapted from previous systems.

Ongoing restructuring has also seen local electricity supply companies privatised and exclusive franchise areas abolished, permitting competition between retail companies for residential, commercial and industrial customers. As a result of these influences, the sector now consists of four major energy retail supply companies and 24 separate network operations. A proportion of the electricity generated is exchanged through a wholesale pool organised by the participants in a private sector wholesale market (M-co) with the remainder subject to term contracts established directly between the generator and consumer.

Operation of the wholesale market ensures that electricity pricing is more responsive to supply and demand on a short-term basis. To prevent market dominance, a system of light-handed regulation was promulgated utilising information disclosure to facilitate price negotiation and backed up by the general provisions of the Commerce Act. The disclosure requirements for monopoly line businesses are more rigorous than for retail and generation businesses and new procedures for establishing transmission prices through the Electricity Governance Board (EGB) are in the process of being implemented.

In forming the market, it was intended that by more closely reflecting the true cost of supply, the market would create the necessary economic signals for investment, efficiency and conservation. This has not always been the case.

Changes in the market structure have been reflected in new patterns of investment and activity by the different industry stakeholders. Over recent years, investments in new generation facilities have added capacity to anticipate demand growth, but with investment not by the traditional central generator but by consortia of electricity purchasers, private generators and technology providers. Up until 2001, the major generation companies were advancing plans for new gas-fired plant, but these have now been deferred. Decisions on these projects are likely be according to project finance requirements rather than any broader national interest objective.

The electricity shortages and high prices in the winters of 2001 and 2003 and growing risk of dry-year shortages have led to further reforms of the industry. New regulations to come into effect in 2003 will provide for the creation of an Electricity Commission to manage dry year reserve capacity for the sector. The Commission will have the power to recover costs through a consumer levy as well as be responsible for forecasting future electricity supply and demand. A better informed market and increased collaboration will go some way towards developing alternative courses of action to manage the increasing risks of supply shortfalls. However, despite this intervention, the underlying need remains to extend reserve capacity.

The need for reserve capacity

All electricity generation and transmission systems must have reserve capacity available to maintain supply in the event of breakdowns of generating plant, loss of major transmission lines, droughts or any other factor which may reduce capacity.

Determination of an appropriate level of reserve capacity is particularly complex within the New Zealand electricity supply system because a large proportion of the generation comes from hydro-electric stations. The new Electricity Commission contracts are intended to meet a 1 in 60 dry year target. The balance between new and existing generation in that portfolio will be critical.

In a normal year, New Zealand needs sufficient base-load generating capacity from hydro, fossil fuels and geothermal to ensure that demand can be met. For dry years, additional generation is needed which has access to a reliable supply of fuel above base load. This role has previously been filled by stations like Huntly and New Plymouth burning large additional quantities of Maui gas. This option is no longer available, and alternatives must be found. This is almost inevitably likely to be thermal generation based on coal or distillate fuels. While some existing plant is likely to be contracted as reserve capacity, new plant will need to be commissioned and fuel stocks maintained. The source of these fuels is a critical issue.

Planned generating plant

The recent investment history of the electricity

> Transpower has recently forecast that, by 2005, assuming high load growth, existing generation is likely to be insufficient to meet demand in a dry year. The earlier than expected Maui gas field depletion also reduces the security margin in dry years as replacement fields are unlikely to provide the same opportunity to ramp up gas supply when required. The Ministry has signalled diminishing electricity supply for some years.
>
> *Ministry of Economic Development, briefing to incoming ministers, 2002*

the sector underscores the vulnerability of electricity generation to any reduction in natural gas supply and increasing vulnerability to delays in commissioning new plant. During the last two years, only 111 MW of new generating plant has been commissioned, about one third of what is required to meet growth.

Of the power stations commissioned in recent years, almost all have been fuelled by natural gas. These include the Otahuhu B and Stratford combined-cycle stations, Southdown Cogeneration Facility, and industrial cogeneration projects at Te Rapa, Te Awamutu, Edgecumbe, Kinleith, Hawera (Fonterra) and Glenbrook. There have also been some non-fossil fuel stations built in this time, including four geothermal stations, two mini hydro stations and two windfarms. Together these add up to approximately 1300 MW installed capacity.

However, more than 400 MW of thermal reserve stations have been taken out of service and, in 2001, Contact Energy postponed their proposed 400 MW Otahuhu C station because of lack of secure gas supply.

CAE/Sinclair Knight Merz outlined a number of possible supply scenarios in 2002 with an aggregate capacity in excess of 3300 MW that, together, would mitigate the risk of supply shortfall in the coming years. In particular, there are a number of options for new generating plant which could be put into service within the next two or three years that could contribute to reducing the risk of electricity shortages between now and 2008, either as base load or reserve power to meet dry year shortfall.

These possibilities include geothermal projects where the exploration has already been done, oil-fired generation at New Plymouth and new coal-fired capacity. Contact Energy have since announced a $10 million upgrade at New Plymouth to allow oil or gas as a fuel, and Mighty River Power are investigating running Marsden B on oil.

Beyond these projects, there are only two major new generating projects currently planned: the 400 MW gas-fired combined cycle unit at Huntly that is proposed for commissioning in 2006 and the Project Aqua hydro proposal on the lower Waitaki River with 285 MW due for 2008 and another 285 MW for 2012. These projects have substantial risks attached to them: fuel supply for the Huntly plant is not assured, and Project Aqua is yet to clear the resource consent process in addition to uncertainties of final configuration.

An evaluation of these factors suggests that New Zealand's electricity industry has yet to come fully to terms with a likely future gas-constrained market. The challenge is not only to ensure that the risk imposed by dry years is managed by having adequate reserve capacity, but to ensure ongoing future supply of primary fuel to meet demand growth patterns.

Other planned power projects that have been reported to total an additional 1370 MW by 2012 include geothermal, coal, distillate, hydro, hydro-irrigation and wind schemes. The largest of these are Contact Energy's 150-190 MW distillate plant at Otahuhu or Whirinaki, Trustpower's 36 MW Tararua wind farm and 115 MW Wairau hydro-irrigation scheme. The proposed projects have varying levels of risk attached to them. Even if all of them were to proceed, they would barely meet growth demand.

Distributed generation

Deregulation of the New Zealand electricity industry has opened the way for entry of new providers as well as new solutions to meeting future demand for electricity and other energy forms. Distributed generation or DG is one such response option.

DG has the potential to:

- reduce the supply-demand gap emerging in New Zealand's electricity supply
- contribute up to 50% of anticipated annual future electricity demand increases
- provide an alternative to expanding the capacity of established electricity transmission and distribution networks
- alleviate constraints on new hydro development and natural gas supply by providing a more diverse energy base for electricity generation.

Proven DG technologies span a wide range of technologies, capacity, and energy sources and have been utilised for a number of years. The picture is often clouded, however, by the emphasis given to the technologies rather than the opportunities, and recent work by CAE has clearly established that a paradigm shift in thinking will be necessary to maximise DG uptake in this country.

There are many possible configurations for the application of DG:

- cogeneration plant at industrial or commercial sites
- stand-by generation using diesel, gas, coal, geothermal and other fuel sources
- generation plant supplying directly into local distribution networks, such as wind farms
- micro-grid (islanded) operation
- electricity storage devices to meet demand peaks
- fuel switching at times of system peaks
- demand side management systems.

Most DG to date has been developed by using established technologies such as reciprocating engines, combustion turbines and small hydro. Developing technologies have yet to approach mature market costs. In all probability, potential in New Zealand for DG up to 2015 will use existing technology and some additional wind power. Developments beyond then will be driven as much by the industry structure of the day and its *modus operandi* as by the technologies available.

DG is not a replacement for electricity supplied through the wholesale market. Rather, DG is a different market, complementary to the wholesale market, with each providing different cost structures and benefits. For example, a secondary DG market can be envisaged involving on-selling or buy-back of surplus electricity capacity. Innovative solutions are often needed to realise such interdependent activities, in both technical and contractual contexts.

In order for DG and demand-side management to be effective, it will be necessary to employ the technologies of the information age. The focus of DG uptake is not about the technologies of conversion, but about the enabling technologies of two-way communication to every customer and plant item on the network using real-time pricing and smart metering, and high-level modelling of the electricity system. It is these enabling technologies that will herald significant changes in supply structures.

The issues that will influence DG uptake focus on dealing with the complexity of the number and type of energy sources, changes in electricity transmission flows, maintenance of local reliability and security, and market integration.

In New Zealand, the electricity market is characterised by few significant load centres and a widely dispersed, lightly loaded, rural network. One percent of all New Zealand electricity customers account for 70% of the total industrial and commercial electricity consumption. Fewer than 150 users have loads within the 1- 5 MW scale, typical of conventional distributed generation modes, and New Zealand is likely to embrace systems of less than 1 MW capacity – quite different from many other developed countries. At this scale, distributed generation is likely to be less technically feasible than alternative energy efficiency options, and questions of system adequacy are likely to be more important than reduced energy consumption.

CAE analysis has identified several specific drivers influencing the DG market:

- niche opportunities for supply based on available waste fuels or renewable sources
- meeting business on-site energy requirements
- more efficient responses to meeting the demand and supply capacity requirements of networks
- incremental investments to meet power quality and standby capacity markets
- renewable energy/carbon trading opportunities
- customer dissatisfaction with existing market access arrangements.

Within this framework, three DG markets have been identified:

- a continuation of current trends based on embedded generation, using conventional technologies such as reciprocating diesel engines and supplemented by limited additional investment in cogeneration

- a second investment stream of small-scale renewable energy generation, based again on conventional technology and facilitated by supportive government policy and market mechanisms
- a future 'engineered' market driven by capacity and access arrangements, and characterised by information technology and key electronic technologies required for sophisticated power management and control to every customer.

These routes overlap . They can merge or remain separate. DG is more widespread and entrenched than generally recognised and within the current industry structure there are both financial and technical risk management drivers for investment in DG.

The key to DG's future will be migrating from this platform to a new energy market focused on customer solutions rather than utility responses. The investments in DG now being made thus provide a pathway to full integration of all three streams. The establishment of an active 'engineered' market will be an essential condition if the full potential for DG opportunities is to be realised.

CAE analysis indicates penetration scenarios summarised in the table below. DG is seen as potentially contributing as much as 40-50% of the anticipated annual future electricity demand increases out to the year 2015. This excludes the contributions from geothermal and wind from conventional centralised power generation modes. To realise this market will require specific government intervention otherwise the contribution from DG will be much less than hoped for. Again, the question needs to be asked – what are the alternative fuel supplies for New Zealand?

TECHNOLOGY	CURRENT AND ASSISTED ROUTES	ENGINEERED MARKET ROUTE
reciprocating engines	20 - 40 MW	250 MW
gas turbines	0 – 20 MW	50 MW
combustion/steam turbine	40 - 80 MW	100 MW
geothermal	20 - 80 MW	100 MW
small scale hydro	10 – 30 MW	80 MW
biomass systems	0 - 5 MW	10 MW
wind	5 - 20 MW (10 - 40 MW installed)	160 MW (350 MW installed)
maximum installed capacity	95 – 275 MW	750 MW

Table 5: Potential distributed generation penetration 2003-2015

towards a vision of the future — planning for improved energy sector performance

In spite of plentiful primary energy resources, New Zealand remains vulnerable to risks of electricity shortages, shortfall in transport fuels supply, increased dependency on imported fuels, and higher costs to consumers. The country must maintain reliability and security of energy supply and with it, the competitive advantage it has gained from energy sector investment over many decades.

Depletion of the Maui field has quickly imposed a new framework for New Zealand's energy future, beginning with a period of transition that is now upon us. How that transition is managed, and what the transition is towards, depends on a complex mix of factors. The first is Government's own policy objectives.

CURRENT ENERGY POLICY

New Zealand's energy policy regime is governed by broad objectives that Government expects industry to achieve:

- environmental sustainability, including continuing improvement in energy efficiency and a progressive transition to renewable sources of energy;
- reliable and secure supply of essential energy services;
- costs and prices to consumers that are as low as possible while ensuring that price reflects the full cost of supply including environmental costs;
- fairness in pricing, so that the least advantaged in the community have access to energy services at reasonable prices; and
- continued public ownership of publicly owned assets.

Within this framework, the Government has taken a number of initiatives that deal with a wide range of energy-related issues.

- Energy efficiency promoted under the National Energy Efficiency and Conservation Strategy of 2001, seeking economy-wide efficiency improvement of at least 20%. The Strategy also sets an ambitious renewable energy target of an extra 30 PJ by 2012.
- Government announcement of the Gas Sector Review in November 2002, carried out to ensure gas delivery to existing and new customers in an efficient, fair, reliable, and sustainable manner. Consistent with this overall objective, the Government is seeking the following specific outcomes:
  - gas and other resources are used efficiently;
  - barriers to gas exploration and field development are minimised;
  - the costs of producing and transporting gas are signalled so that investors and consumers can make decisions consistent with obtaining the most value from gas;
  - delivered gas costs and prices are subject to sustained downward pressure;
  - risks relating to security of supply, including transport arrangements, are properly and efficiently managed by all parties;
  - gas safety is promoted; and
  - greenhouse gas emissions are minimised.
- Government expectations on the energy industry to develop arrangements with respect to: production and wholesale markets, transmission and distribution networks (including access to high-pressure transmission pipelines) and retail markets. Government has stated that it is prepared to use regulatory solutions where necessary.
- A policy package on climate change has been confirmed to assist New Zealand to meet its international obligations under the Kyoto Protocol and move towards a sustainable energy future. The foundation policies of the climate change package are the Growth and Innovation Framework, the National Energy Efficiency and Conservation Strategy, the New Zealand Transport Strategy (under development), the New Zealand Waste Strategy, climate change research, and a partnership with local

government in addressing climate change at a local level.

- Announcement by Government of a programme of action in respect of energy under its broader sustainable development objectives. Desired outcomes include:
  - energy use in New Zealand becomes progressively more efficient and less wasteful
  - renewable sources of energy are developed and maximised
  - New Zealand consumers have a secure supply of electricity.
- Announcement by Government in June 2003 of the formation of an Electricity Commission to incentivise the provision of reserve generation capacity in very dry years and the necessary investment in the national grid to proceed.
- Crown Minerals of the Ministry of Economic Development is actively promoting hydrocarbon exploration opportunities to the global exploration market, but with very limited resources to date.
- Through the science funding system, Government contributes about $4.5 million each year for underpinning research on New Zealand hydrocarbon potential, mainly through the Crown-owned Institute of Geological and Nuclear Sciences.

Together, these policy statements and programmes reflect a strong desire for sustainable development of the economy, reflecting the dependence of modern society on access to energy at reasonable price and the strong links between energy availability and economic growth. The question that needs to asked, however, is whether the broad framework outlined by Government is sufficient to meet the needs of this country and its people.

The issues identified in this commentary and by others indicate that the current policy and institutional arrangements are not effectively working despite targeting of some key issues by Government initiatives. Having progressively shifted the delivery of energy services from a centrally planned and managed system, the nation now depends on an imperfect market to deliver continuously through the necessary transition to an energy future without Maui gas. Overseas experience casts serious doubt on the viability of such market solutions, indicating that further Government intervention will be required to avoid serious negative economic, social and environmental impacts.

SETTING PRIORITIES FOR ENERGY SUPPLY

Although Government policy objectives for environmental sustainability and a progressive transition to renewable energy sources are vitally important, thinking is required that goes beyond just maximising renewable energy contributions and energy efficiency. New Zealand has lost control of its tactical response to short-term energy requirements and, apart from well-defined coal resources, its strategic primary energy supply.

An examination of the recent investment history within the electricity sector underscores the vulnerability of generation to disruption of natural gas supplies in the absence sufficient market incentives to use alternatives (such as coal as a dry-year hedge), and to meet growth. A lack of planning centred on the delivery of primary energy supply is what has led to New Zealand's increasing vulnerability to delays in commissioning new generating plant and an increased reliance on imported sources of primary energy.

A necessary, additional component, often ignored is the infrastructure needs to ensure access to our energy resource base. On balance New Zealand indigenous energy sources are far removed from major load centres. A transition from gas to coal, for example, will shift energy supply to new regions unused to the engineering and transport activities related to energy production and distribution. New Zealand simply does not have the infrastructure in place to meet these

> The [2003] crisis is fundamentally different and much worse than the other post-1990 supply shortages, because it is policy-based and will require significant policy changes, well designed and implemented, to overcome it.
>
> *Kerry McDonald, Managing Director, Comalco New Zealand May 2003*

> ‘We must look at the issues in totality and not analyse segments without realising the interaction with other segments. To make the correct judgements for New Zealand we need a total rather than a localised picture – without this serious errors will be made.’
>
> *Colin Martin, CAE Director*

demands. In the absence of long term planning we are unlikely to see the fixed infrastructure investments necessary to facilitate ongoing energy exploration and development.

The way forward needs to be rethought if New Zealand as a society is to have the secure supply of essential energy services on which it depends and at reasonable cost. A more robust route towards assessment of supply and demand is needed that looks at energy sector issues in an interrelated way, rather than dealing with its parts. Only an holistic view will derive the equations for success. The security Maui gas gave New Zealand can no longer be a fall back for the obvious failure of industry and government to deliver the solutions required.

First, and foremost, the transition from dependence on Maui gas to other and preferably renewable forms of energy will need to be managed assertively if New Zealand is to avoid energy shortfalls that would be potentially crippling to the economy. Leaving the markets to signal the right investment decisions while Government hopes for improved efficiency and renewable substitutes will not work if the markets, for example, are not signalling future needs within a meaningful time frame to enable appropriate infrastructure investment.

Without strong coherent action, New Zealand is in danger of reverting to a situation where it becomes once more dependent upon and vulnerable to global oil markets. Demand-side solutions can do nothing to counteract this negative sum game. If this country does nothing to secure adequate indigenous primary energy sources, the alternative is to import. The questions then become from where, at what price and for how long?

There is no obvious answer to these questions. Nor is there any single action, or silver bullet, available to this country. The nature of New Zealand’s resource base, the size of its energy markets, and its patterns of energy use limit the options available. All options need to be evaluated and, by standing in the future, a coherent programme of viable solutions put in place to meet desired outcomes.

Market structures and governance need to be improved to optimise existing capacity and to secure investment in additional capacity sufficient to cover future demand. Our thinking needs to take account of several unique factors in both supply – the resource endowment and its development to date – and demand. The ideal market will be well-informed, and free of distortions. A policy regime to foster strategic thinking is a critical component to enable New Zealand to responded effectively to the challenges it faces.

From a risk point of view, New Zealand needs to consider what levels of vulnerability are acceptable, both from a tactical (short-term) and strategic (long-term) perspective. There are three essential strands to the energy supply risk equation and the responses required to address them (see box):

- extending New Zealand’s primary resources;
- development of a strategic reserve capacity; and
- long-term investment in alternative solutions.

New Zealand is simply not dealing with these three key platforms for a secure energy future. Responding to them will go a long way towards reducing the risks to New Zealand of increasing dependency on foreign oil and electricity supply shortfalls. From an industry perspective, the improved certainty of energy supplies will improve investment confidence with consequent economic benefits. However, to bring these strands together requires thinking at a holistic level. Alternatives to current planning frameworks need to be considered and, in particular, there is an urgent need to consider the national interest ahead of vested interests in key development projects.

This commentary reinforces the view that, after twenty years of neglect, the New Zealand energy sector is now once more at a cross-roads not dissimilar to where it was in the 1970s, prior to Maui and when several large, coal-fired power stations or nuclear power were being considered. Industry needs to re-examine its role in the wider New Zealand context. Government needs to rethink how it can facilitate and encourage the necessary investments in critical energy infrastructure. Current Government goals that are target driven will not drive the required outcomes. Instead, a shift in thinking is required. Goals need to be linked to responses supported by performance indicators.

This commentary offers three performance measures that if examined, adopted and expanded into an agreed industry strategy would offer a framework for future planning and investment. For New Zealand to sustain any reasonable level of economic growth, the performance measures must be:

- minimum levels for self-sufficiency in primary fuels
- appropriate dry year margins
- acceptable levels of reserve capacity and system reliability.

It is within this framework that the desired transition to renewable energy and a fully sustainable energy future can be plotted.

FUTURE ENERGY SUPPLY OPTIONS

Some of the energy supply response options highlighted by this commentary are outlined below. The list is not exhaustive, nor is it intended to suggest priority or relative importance. The options are enumerated simply to encourage wider thinking than has occurred so far.

Extending New Zealand's primary energy resources:

- Increase investment in hydrocarbon exploration, particularly to improve the level of wildcat drilling and international involvement. A concerted effort is needed to identify mid-sized companies with the right exploration interests and promote New Zealand opportunities to them.
- Re-examine the Maui contract terms so as to optimise production profiles until completion, and encourage investment in incremental Maui production.
- Accelerate development of coal resources.
- Target assistance to renewable energy options that contribute to primary energy reserves.
- Review the identified regulatory barriers to investment in hydro, geothermal, wind power and other 'new renewable' generation options.
- Initiate an industry-level study directed towards optimisation of existing networks and systems to improve energy distribution and transport.
- Encourage uptake of distributed generation market opportunities.

Development of a strategic energy reserve capacity:

- Initiate an industry-level study of distillate storage and other possibilities for increased reserves capacity, including coal and LPG.
- Review network security and establish industry agreement on collective action to mitigate identified network constraints.
- Obtain voluntary agreements on Maui pipeline operation and access arrangements following on from the gas sector review.
- Invest in additional network and distribution facilities to enable fuel switching.
- Encourage a strategic level of imports to extend current reserves.

Long-term investment in alternative solutions:

- Accelerate investigations into inferred energy sources such as gas hydrates and coal bed methane.
- Investigate the trade-off between renewable sources and fossil fuels generation from a perspective of energy system reliability.
- Carry out a wide-ranging review of the transport sector to improve access and mobility, and to remove barriers to the need to change transport patterns within New Zealand cities.
- Examine gasification and poly-generation projects.
- Lift support for demand-side management, placing communication of real-time information in the hands of customers, so that it becomes an effective contributor to New Zealand's energy budget.
- Support new renewables technologies that have the effect of facilitating an economic transition to a sustainable energy supply.
- Encourage, through specific intervention, the exploration of the New Zealand's deep water hydrocarbon prospects.